REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	JUNE 1995	Final Remedial Investigation

4. TITLE AND SUBTITLE
Installation Restoration Program Remedial Investigation Report Vol. V
Alpena Combat Readiness Training Center
Alpena MI

5. FUNDING NUMBERS
PRTDVG957097

6. AUTHOR(S)
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
EARTH TECH
Oak Ridge TN

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Hazardous Waste Remedial Actions Program
Martin Marietta Energy Systems, Inc.
Oak Ridge, TN 37831

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
RG-07-159-0370

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release;
distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Remedial Investigation Report of Sites 1-9 at Alpens CRTC, Alpena MI. Volume V Appendicies P-W. A remedial investigation was performed on 9 sites at the Alpena CRTC to determine the extent of contamination at the sites. The sites involved in this investigation include: Site 1 POL Storage Area; Site 2 Motor Pool Area; Site 3 Former Garage; Site 4 Third Fire Training Area; Site 5 Second Fire Training Area; Site 6 Former Landfill; Site 7 First Fire Training Area; Site 8 Former Hanger 9; Site 10 Hazardous Waste Storage Area. Soil and groundwater contamination above state action levels was found at the sites. An FS has been initiated.

14. SUBJECT TERMS
Installation Restoration Program; Air National Guard; Remedial Investigation; Alpena CRTC; Alpena MI, ANG

15. NUMBER OF PAGES
284

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	NONE

GENERAL INSTRUCTIONS FOR COMPLETING SF 298

The Report Documentation Page (RDP) is used in announcing and cataloging reports. It is important that this information be consistent with the rest of the report, particularly the cover and title page. Instructions for filling in each block of the form follow. It is important to ***stay within the lines*** to meet ***optical scanning requirements***.

Block 1. Agency Use Only *(Leave blank)*.

Block 2. Report Date. Full publication date including day, month, and year, if available (e.g. 1 Jan 88). Must cite at least the year.

Block 3. Type of Report and Dates Covered. State whether report is interim, final, etc. If applicable, enter inclusive report dates (e.g. 10 Jun 87 - 30 Jun 88).

Block 4. Title and Subtitle. A title is taken from the part of the report that provides the most meaningful and complete information. When a report is prepared in more than one volume, repeat the primary title, add volume number, and include subtitle for the specific volume. On classified documents enter the title classification in parentheses.

Block 5. Funding Numbers. To include contract and grant numbers; may include program element number(s), project number(s), task number(s), and work unit number(s). Use the following labels:

C -	Contract	**PR** -	Project
G -	Grant	**TA** -	Task
PE -	Program Element	**WU** -	Work Unit Accession No.

Block 6. Author(s). Name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. If editor or compiler, this should follow the name(s).

Block 7. Performing Organization Name(s) and Address(es). Self-explanatory.

Block 8. Performing Organization Report Number. Enter the unique alphanumeric report number(s) assigned by the organization performing the report.

Block 9. Sponsoring/Monitoring Agency Name(s) and Address(es). Self-explanatory.

Block 10. Sponsoring/Monitoring Agency Report Number. *(If known)*

Block 11. Supplementary Notes. Enter information not included elsewhere such as: Prepared in cooperation with...; Trans. of...; To be published in.... When a report is revised, include a statement whether the new report supersedes or supplements the older report.

Block 12a. Distribution/Availability Statement. Denotes public availability or limitations. Cite any availability to the public. Enter additional limitations or special markings in all capitals (e.g. NOFORN, REL, ITAR).

DOD - See DoDD 5230.24, "Distribution Statements on Technical Documents."
DOE - See authorities.
NASA - See Handbook NHB 2200.2.
NTIS - Leave blank.

Block 12b. Distribution Code.

DOD - Leave blank.
DOE - Enter DOE distribution categories from the Standard Distribution for Unclassified Scientific and Technical Reports.
NASA - Leave blank.
NTIS - Leave blank.

Block 13. Abstract. Include a brief *(Maximum 200 words)* factual summary of the most significant information contained in the report.

Block 14. Subject Terms. Keywords or phrases identifying major subjects in the report.

Block 15. Number of Pages. Enter the total number of pages.

Block 16. Price Code. Enter appropriate price code *(NTIS only)*.

Blocks 17. - 19. Security Classifications. Self-explanatory. Enter U.S. Security Classification in accordance with U.S. Security Regulations (i.e., UNCLASSIFIED). If form contains classified information, stamp classification on the top and bottom of the page.

Block 20. Limitation of Abstract. This block must be completed to assign a limitation to the abstract. Enter either UL (unlimited) or SAR (same as report). An entry in this block is necessary if the abstract is to be limited. If blank, the abstract is assumed to be unlimited.

INSTALLATION RESTORATION PROGRAM

FINAL
REMEDIAL INVESTIGATION REPORT

VOLUME V: APPENDICES P - W

ALPENA COMBAT READINESS TRAINING CENTER
ALPENA COUNTY REGIONAL AIRPORT, MICHIGAN AIR NATIONAL GUARD
ALPENA, MICHIGAN

JUNE 1995

HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
Environmental Restoration and Waste Management Programs
Oak Ridge, Tennessee 37831-7606
managed by MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the U.S. DEPARTMENT OF ENERGY under contract DE-AC05-84OR21400

TABLE OF CONTENTS

REMEDIAL INVESTIGATION REPORT
ALPENA COMBAT READINESS TRAINING CENTER
MICHIGAN AIR NATIONAL GUARD
ALPENA, MICHGIAN

Volume V

Appendix

Table P-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 1
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0820
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	1,4-Dichlorobenzene	25.0000
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Antimony, Dissolved	39.2000
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Antimony, Dissolved	17.5000
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Antimony, Dissolved	39.2000
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Benzene	13.0000
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Benzene	0.6000
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Benzene	0.1750
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Benzene	0.1750
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Benzene	0.1100
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Benzene	0.1750
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Benzene	0.0900
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Benzene	0.1750
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Benzene	10.0000
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Bromodichloromethane	0.7800
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Bromodichloromethane	0.2000
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Dibenzofuran	2.5000

Table P-1A (continued)
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 1
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Dibenzofuran	2.5000
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Dibenzofuran	1.0000
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Dibromochloromethane	2.1000
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Dibromochloromethane	0.1500
PC-P1	MW1	PC-P1-MW1-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW11	PC-P1-MW11-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW12	PC-P1-MW12-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW13	PC-P1-MW13-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW14	PC-P1-MW14-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW2	PC-P1-MW2-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW3	PC-P1-MW3-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW4	PC-P1-MW4-GW4	GROUNDWATER	Styrene	0.1250
PC-P1	MW6	PC-P1-MW6-GW4	GROUNDWATER	Styrene	8.5000
PC-PW	PW1	PC-PW-PW1-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-PW	PW2	PC-PW-PW2-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-PW	PW3	PC-PW-PW3-GW4	GROUNDWATER	Carbon Tetrachloride	1.2000

Table P-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Sediment - Site 1
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE		RESULT
PC-P1	SD001	PC-P1-SD001	SEDIMENT	Arsenic	0.0000	0.0000	3.0000
PC-P1	SD002	PC-P1-SD002	SEDIMENT	Arsenic	0.0000	0.0000	5.8000
PC-P1	SD003	PC-P1-SD003	SEDIMENT	Arsenic	0.0000	0.0000	0.9600
PC-P1	SD005	PC-P1-SD005	SEDIMENT	Arsenic	0.0000	0.0000	3.4000
PC-P1	SD001	PC-P1-SD001	SEDIMENT	Copper	0.0000	0.0000	2.3000
PC-P1	SD002	PC-P1-SD002	SEDIMENT	Copper	0.0000	0.0000	5.3000
PC-P1	SD003	PC-P1-SD003	SEDIMENT	Copper	0.0000	0.0000	0.9500
PC-P1	SD005	PC-P1-SD005	SEDIMENT	Copper	0.0000	0.0000	24.0000

Table P-3A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Subsoils - Site 1
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE		RESULT
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Chlorobenzene	0.0000	0.0000	2.1000
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Chlorobenzene	0.0000	0.0000	6200.0000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Chlorobenzene	0.0000	0.0000	1.9000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Chlorobenzene	0.0000	0.0000	0.3100
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Chlorobenzene	0.0000	0.0000	2.0000
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Chlorobenzene	0.0000	0.0000	1.9000
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Ethylbenzene	0.0000	0.0000	0.2000
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Ethylbenzene	0.0000	0.0000	7900.0000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Ethylbenzene	0.0000	0.0000	1.9000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Ethylbenzene	0.0000	0.0000	0.1400
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Ethylbenzene	0.0000	0.0000	2.0000
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Ethylbenzene	0.0000	0.0000	1.9000
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Styrene	0.0000	0.0000	1.8000
PC-P1	SB01	PC-P1-SB01	SUBSOIL	Styrene	0.0000	0.0000	7800.0000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Styrene	0.0000	0.0000	1.6000
PC-P1	SB02	PC-P1-SB02	SUBSOIL	Styrene	0.0000	0.0000	0.6600
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Styrene	0.0000	0.0000	1.7000
PC-P1	SB03	PC-P1-SB03	SUBSOIL	Styrene	0.0000	0.0000	1.6000

TABLE P-1 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF GROUNDWATER
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	RECREATIONAL/ON-SITE ADULT	CHILD
Ingestion Rate (L/day)	2	2
Exposure Frequency (days/year)	298 *	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

*Worst case scenario assumes the facility employee and recreational adult are the same person. The facility employee is on-site 250 days/year as an employee and uses the recreational facilities an additional 48 days/year for a total exposure frequency of 298 days/year.

TABLE P-2 DAILY INTAKE - ADULT
INGESTION OF SHALLOW AQUIFER PRODUCTION WELL GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.700E-04	2	298	25	70	9125	6.298E-06
Antimony, Dissolved	1.400E-03	2	298	25	70	9125	3.266E-05
Bromodichloromethane	9.000E-06	2	298	25	70	9125	2.099E-07
Dibromochloromethane	2.600E-05	2	298	25	70	9125	6.065E-07
Dibenzofuran	5.000E-06	2	298	25	70	9125	1.166E-07
1,4-Dichlorobenzene	1.500E-06	2	298	25	70	9125	3.499E-08
Styrene	2.600E-06	2	298	25	70	9125	6.065E-08
Carbon Tetrachloride	1.200E-03	2	298	25	70	9125	2.799E-05

TABLE P-3 DAILY INTAKE - CHILD
INGESTION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.700E-04	2.000	48	15	27	5475	2.630E-06
Antimony, Dissolved	1.400E-03	2.000	48	15	27	5475	1.364E-05
Bromodichloromethane	9.000E-06	2.000	48	15	27	5475	8.767E-08
Dibromochloromethane	2.600E-05	2.000	48	15	27	5475	2.533E-07
Dibenzofuran	5.000E-06	2.000	48	15	27	5475	4.871E-08
1,4-Dichlorobenzene	1.500E-06	2.000	48	15	27	5475	1.461E-08
Styrene	2.600E-06	2.000	48	15	27	5475	2.533E-08
Carbon Tetrachloride	1.200E-03	2.000	48	15	27	5475	1.169E-05

TABLE P-4 DAILY INTAKE - ADULT
INGESTION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.700E-04	2	298	25	70	25550	2.249E-06
Antimony, Dissolved	1.400E-03	2	298	25	70	25550	1.166E-05
Bromodichloromethane	9.000E-06	2	298	25	70	25550	7.498E-08
Dibromochloromethane	2.600E-05	2	298	25	70	25550	2.166E-07
Dibenzofuran	5.000E-06	2	298	25	70	25550	4.166E-08
1,4-Dichlorobenzene	1.500E-06	2	298	25	70	25550	1.250E-08
Styrene	2.600E-06	2	298	25	70	25550	2.166E-08
Carbon Tetrachloride	1.200E-03	2	298	25	70	25550	9.997E-06

TABLE P-5 DAILY INTAKE - CHILD
INGESTION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.700E-04	2.000	48	15	27	25550	5.636E-07
Antimony, Dissolved	1.400E-03	2.000	48	15	27	25550	2.922E-06
Bromodichloromethane	9.000E-06	2.000	48	15	27	25550	1.879E-08
Dibromochloromethane	2.600E-05	2.000	48	15	27	25550	5.427E-08
Dibenzofuran	5.000E-06	2.000	48	15	27	25550	1.044E-08
1,4-Dichlorobenzene	1.500E-06	2.000	48	15	27	25550	3.131E-09
Styrene	2.600E-06	2.000	48	15	27	25550	5.427E-09
Carbon Tetrachloride	1.200E-03	2.000	48	15	27	25550	2.505E-06

TABLE P-6 EXPOSURE ASSESSMENT PARAMETERS - INHALATION OF GROUNDWATER
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Exposure Time (hours/day)	0.12	0.12
Inhalation Rate (cu m/hr)	0.6	0.6
Exposure Frequency (days/yr)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE P-7 DAILY INTAKE - ADULT
INHALATION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.550E-03	0.6	298	0.12	25	70	9125	2.142E-06
Antimony, Dissolved		0.6	298	0.12	25	70	9125	0.000E+00
Bromodichloromethane	8.501E-05	0.6	298	0.12	25	70	9125	7.139E-08
Dibromochloromethane	2.456E-04	0.6	298	0.12	25	70	9125	2.062E-07
Dibenzofuran		0.6	298	0.12	25	70	9125	0.000E+00
1,4-Dichlorobenzene	1.417E-05	0.6	298	0.12	25	70	9125	1.190E-08
Styrene	2.456E-05	0.6	298	0.12	25	70	9125	2.062E-08
Carbon Tetrachloride	1.134E-02	0.6	298	0.12	25	70	9125	9.519E-06

TABLE P-8 DAILY INTAKE - CHILD
INHALATION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.550E-03	0.6	48	0.12	15	27	5475	8.944E-07
Antimony, Dissolved		0.6	48	0.12	15	27	5475	0.000E+00
Bromodichloromethane	8.501E-05	0.6	48	0.12	15	27	5475	2.981E-08
Dibromochloromethane	2.456E-04	0.6	48	0.12	15	27	5475	8.613E-08
Dibenzofuran		0.6	48	0.12	15	27	5475	0.000E+00
1,4-Dichlorobenzene	1.417E-05	0.6	48	0.12	15	27	5475	4.969E-09
Styrene	2.456E-05	0.6	48	0.12	15	27	5475	8.613E-09
Carbon Tetrachloride	1.134E-02	0.6	48	0.12	15	27	5475	3.975E-06

TABLE P-9 DAILY INTAKE - ADULT
INHALATION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.550E-03	0.6	298	0.12	25	70	25550	7.649E-07
Antimony, Dissolved		0.6	298	0.12	25	70	25550	0.000E+00
Bromodichloromethane	8.501E-05	0.6	298	0.12	25	70	25550	2.550E-08
Dibromochloromethane	2.456E-04	0.6	298	0.12	25	70	25550	7.366E-08
Dibenzofuran		0.6	298	0.12	25	70	25550	0.000E+00
1,4-Dichlorobenzene	1.417E-05	0.6	298	0.12	25	70	25550	4.250E-09
Styrene	2.456E-05	0.6	298	0.12	25	70	25550	7.366E-09
Carbon Tetrachloride	1.134E-02	0.6	298	0.12	25	70	25550	3.400E-06

TABLE P-10 DAILY INTAKE - CHILD
INHALATION OF SHALLOW AQUIFER GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	2.550E-03	0.6	48	0.12	15	27	25550	1.917E-07
Antimony, Dissolved		0.6	48	0.12	15	27	25550	0.000E+00
Bromodichloromethane	8.501E-05	0.6	48	0.12	15	27	25550	6.389E-09
Dibromochloromethane	2.456E-04	0.6	48	0.12	15	27	25550	1.846E-08
Dibenzofuran		0.6	48	0.12	15	27	25550	0.000E+00
1,4-Dichlorobenzene	1.417E-05	0.6	48	0.12	15	27	25550	1.065E-09
Styrene	2.456E-05	0.6	48	0.12	15	27	25550	1.846E-09
Carbon Tetrachloride	1.134E-02	0.6	48	0.12	15	27	25550	8.518E-07

TABLE P-11 GROUNDWATER INHALATION MODEL CALCULATIONS
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemicals	Chemical Concentration (mg/L)	Fraction Volatilized (unitless)	Water Flow Rate (L/hr)	Showering Duration Period (hr)	Post Showering Duration Period (hr)	Bathroom Volume (cu m)	Showering Maximum Contaminant Concn'n in Air (mg/cu m)	During and After Showering MAX Contaminant Concn'n in Air (mg/cu m)
Benzene	2.700E-04	0.7	750	0.25	0.35	11	3.222E-03	2.550E-03
Antimony, Dissolved	1.400E-03	0.7	750	0.25	0.35	11	1.670E-02	1.322E-02
Bromodichloromethane	9.000E-06	0.7	750	0.25	0.35	11	1.074E-04	8.501E-05
Dibromochloromethane	2.600E-05	0.7	750	0.25	0.35	11	3.102E-04	2.456E-04
Dibenzofuran	5.000E-06	0.7	750	0.25	0.35	11	5.966E-05	4.723E-05
1,4-Dichlorobenzene	1.500E-06	0.7	750	0.25	0.35	11	1.790E-05	1.417E-05
Styrene	2.600E-06	0.7	750	0.25	0.35	11	3.102E-05	2.456E-05
Carbon Tetrachloride	1.200E-03	0.7	750	0.25	0.35	11	1.432E-02	1.134E-02

TABLE P-12 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH GROUNDWATER
Site 1, Former POL Facilty, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	0.25	0.25
Dermal Permeability Constant *	0.00084	0.00084
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	

* Predicted PC (Table 5-7 of U.S. EPA, 1992a)

TABLE P-13 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	(a)	2.700E-04	0.1	19400	298	0.25	25	70	9125	0.001	1.527E-06
Antimony, Dissolved	(c)	1.400E-03	0.001	19400	298	0.25	25	70	9125	0.001	7.919E-08
Bromodichloromethane	(b)	9.000E-06	0.0058	19400	298	0.25	25	70	9125	0.001	2.953E-09
Dibromochloromethane	(b)	2.600E-05	0.0039	19400	298	0.25	25	70	9125	0.001	5.736E-09
Dibenzofuran		5.000E-06	0.00084	19400	298	0.25	25	70	9125	0.001	2.376E-10
1,4-Dichlorobenzene	(b)	1.500E-06	0.062	19400	298	0.25	25	70	9125	0.001	5.261E-09
Styrene		2.600E-06	0.00084	19400	298	0.25	25	70	9125	0.001	1.235E-10
Carbon Tetrachloride		1.200E-03	0.022	19400	298	0.25	25	70	9125	0.001	1.493E-06

(a) Experimentally measured PC (Table 5-3 of U. S. EPA, 1992a).
(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC valuew (Table 5-3 of U. S. EPA, 1992a).

TABLE P-14 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	(a)	2.700E-04	0.1	13300	48	0.25	15	27	5475	0.001	4.373E-07
Antimony, Dissolved	(c)	1.400E-03	0.001	13300	48	0.25	15	27	5475	0.001	2.267E-08
Bromodichloromethane	(b)	9.000E-06	0.0058	13300	48	0.25	15	27	5475	0.001	8.454E-10
Dibromochloromethane	(b)	2.600E-05	0.0039	13300	48	0.25	15	27	5475	0.001	1.642E-09
Dibenzofuran		5.000E-06	0.00084	13300	48	0.25	15	27	5475	0.001	6.802E-11
1,4-Dichlorobenzene	(b)	1.500E-06	0.062	13300	48	0.25	15	27	5475	0.001	1.506E-09
Styrene		2.600E-06	0.00084	13300	48	0.25	15	27	5475	0.001	3.537E-11
Carbon Tetrachloride		1.200E-03	0.022	13300	48	0.25	15	27	5475	0.001	4.275E-07

(a) Experimentally measured PC (Table 5-3 of U. S. EPA, 1992a).
(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC valuew (Table 5-3 of U. S. EPA, 1992a).

TABLE P-15 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	(a)	2.700E-04	0.1	19400	298	0.25	25	70	25550	0.001	5.455E-07
Antimony, Dissolved	(c)	1.400E-03	0.001	19400	298	0.25	25	70	25550	0.001	2.828E-08
Bromodichloromethane	(b)	9.000E-06	0.0058	19400	298	0.25	25	70	25550	0.001	1.055E-09
Dibromochloromethane	(b)	2.600E-05	0.0039	19400	298	0.25	25	70	25550	0.001	2.049E-09
Dibenzofuran		5.000E-06	0.00084	19400	298	0.25	25	70	25550	0.001	8.485E-11
1,4-Dichlorobenzene	(b)	1.500E-06	0.062	19400	298	0.25	25	70	25550	0.001	1.879E-09
Styrene		2.600E-06	0.00084	19400	298	0.25	25	70	25550	0.001	4.412E-11
Carbon Tetrachloride		1.200E-03	0.022	19400	298	0.25	25	70	25550	0.001	5.334E-07

(a) Experimentally measured PC (Table 5-3 of U. S. EPA, 1992a).
(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC valuew (Table 5-3 of U. S. EPA, 1992a).

TABLE P-16 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	(a)	2.700E-04	0.1	13300	48	0.25	15	27	25550	0.001	9.370E-08
Antimony, Dissolved	(c)	1.400E-03	0.001	13300	48	0.25	15	27	25550	0.001	4.858E-09
Bromodichloromethane	(b)	9.000E-06	0.0058	13300	48	0.25	15	27	25550	0.001	1.812E-10
Dibromochloromethane	(b)	2.600E-05	0.0039	13300	48	0.25	15	27	25550	0.001	3.519E-10
Dibenzofuran		5.000E-06	0.00084	13300	48	0.25	15	27	25550	0.001	1.458E-11
1,4-Dichlorobenzene	(b)	1.500E-06	0.062	13300	48	0.25	15	27	25550	0.001	3.227E-10
Styrene		2.600E-06	0.00084	13300	48	0.25	15	27	25550	0.001	7.579E-12
Carbon Tetrachloride		1.200E-03	0.022	13300	48	0.25	15	27	25550	0.001	9.162E-08

(a) Experimentally measured PC (Table 5-3 of U. S. EPA, 1992a).
(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC valuew (Table 5-3 of U. S. EPA, 1992a).

TABLE P-17 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH SOILS
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Skin Surface Area Available for Contact (cm^2/day)	3120
Soil to Skin Adherence Factor (mg/cm^2)	2.77
Absorption Factor, Unitless	
Metals	0.01
Organics	0.25
Exposure Factor (days/year)	250
Exposure Duration (year)	0.08
Body Weight (kilograms)	70
Conversion Factor	1E-06
Averaging Time, years	0.08

TABLE P-18 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Chlorobenzene	3.116E+00	1.00E-06	3120	2.77	0.25	250	0.08	70	29.2	6.588E-05
Ethylbenzene	3.970E+00	1.00E-06	3120	2.77	0.25	250	0.08	70	29.2	8.394E-05
Styrene	3.920E+00	1.00E-06	3120	2.77	0.25	250	0.08	70	29.2	8.288E-05

TABLE P-19 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Chlorobenzene	3.116E+00	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	7.529E-08
Ethylbenzene	3.970E+00	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	9.593E-08
Styrene	3.920E+00	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	9.472E-08

TABLE P-20 EXPOSURE ASSESSMENT PARAMETERS - SOIL INGESTION
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Ingestion Rate (mg/day)	480
Fraction Ingested from	
Contaminated Sources (unitless)	1
Exposure Frequency (days/year)	250
Exposure Duration (years)	0.08
Body Weight (kilograms)	70
Conversion Factor	1E-06
Averaging Time	
Carcinogenic	70
Noncarcinogenic	0.08

TABLE P-21 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Excavation Worker Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Excavation Worker Intake Rate (mg/kg-day)
Chlorobenzene	3.116E+03	1E-06	480	1	250	0.08	70	29.2	1.464E-02
Ethylbenzene	3.970E+03	1E-06	480	1	250	0.08	70	29.2	1.865E-02
Styrene	3.920E+03	1E-06	480	1	250	0.08	70	29.2	1.841E-02

TABLE P-22 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION AND PLANT EMPLOYEES

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Excavation Worker Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Excavation Worker Intake Rate (mg/kg-day)
Chlorobenzene	3.116E+03	1E-06	480	1	250	0.08	70	25550	1.673E-05
Ethylbenzene	3.970E+03	1E-06	480	1	250	0.08	70	25550	2.131E-05
Styrene	3.920E+03	1E-06	480	1	250	0.08	70	25550	2.104E-05

TABLE P-23 EXPOSURE ASSESSMENT PARAMETERS - FISH INGESTION
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Fraction of Fish Ingested, unitless	0.5	0.5
Ingestion rate kg/day	0.054	0.043
Exposure Frequency days/yr	26	26
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE P-24 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	3.840E-03	0.054	26	0.5	25	70	9125	1.055E-07
Antimony, Dissolved	9.000E-06	0.054	26	0.5	25	70	9125	2.473E-10
Bromodichloromethane	6.900E-04	0.054	26	0.5	25	70	9125	1.896E-08
Dibromochloromethane	3.450E-05	0.054	26	0.5	25	70	9125	9.479E-10
Dibenzofuran	5.000E-06	0.054	26	0.5	25	70	9125	1.374E-10
1,4-Dichlorobenzene	1.200E-04	0.054	26	0.5	25	70	9125	3.297E-09
Styrene	6.500E-01	0.054	26	0.5	25	70	9125	1.786E-05
Carbon Tetrachloride	1.000E-05	0.054	26	0.5	25	70	9125	2.748E-10

TABLE P-25 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	3.840E-03	0.043	26	0.5	15	27	5475	2.178E-07
Antimony, Dissolved	9.000E-06	0.043	26	0.5	15	27	5475	5.105E-10
Bromodichloromethane	6.900E-04	0.043	26	0.5	15	27	5475	3.914E-08
Dibromochloromethane	3.450E-05	0.043	26	0.5	15	27	5475	1.957E-09
Dibenzofuran	5.000E-06	0.043	26	0.5	15	27	5475	2.836E-10
1,4-Dichlorobenzene	1.200E-04	0.043	26	0.5	15	27	5475	6.807E-09
Styrene	6.500E-01	0.043	26	0.5	15	27	5475	3.687E-05
Carbon Tetrachloride	1.000E-05	0.043	26	0.5	15	27	5475	5.672E-10

TABLE P-26 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	3.840E-03	0.054	26	0.5	25	70	25550	3.768E-08
Antimony, Dissolved	9.000E-06	0.054	26	0.5	25	70	25550	8.831E-11
Bromodichloromethane	6.900E-04	0.054	26	0.5	25	70	25550	6.771E-09
Dibromochloromethane	3.450E-05	0.054	26	0.5	25	70	25550	3.385E-10
Dibenzofuran	5.000E-06	0.054	26	0.5	25	70	25550	4.906E-11
1,4-Dichlorobenzene	1.200E-04	0.054	26	0.5	25	70	25550	1.178E-09
Styrene	6.500E-01	0.054	26	0.5	25	70	25550	6.378E-06
Carbon Tetrachloride	1.000E-05	0.054	26	0.5	25	70	25550	9.813E-11

TABLE P-27 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	3.840E-03	0.043	26	0.5	15	27	25550	4.667E-08
Antimony, Dissolved	9.000E-06	0.043	26	0.5	15	27	25550	1.094E-10
Bromodichloromethane	6.900E-04	0.043	26	0.5	15	27	25550	8.387E-09
Dibromochloromethane	3.450E-05	0.043	26	0.5	15	27	25550	4.193E-10
Dibenzofuran	5.000E-06	0.043	26	0.5	15	27	25550	6.077E-11
1,4-Dichlorobenzene	1.200E-04	0.043	26	0.5	15	27	25550	1.459E-09
Styrene	6.500E-01	0.043	26	0.5	15	27	25550	7.901E-06
Carbon Tetrachloride	1.000E-05	0.043	26	0.5	15	27	25550	1.215E-10

TABLE P-28 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF SURFACE WATER
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	RECREATIONAL ADULT	RECREATIONAL CHILD
Exposure Time (hrs/day)	2.6	2.6
Surface Water Contact Rate (ml/hr)	50	50
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE P-29 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	1.60E-04	0.050	48	2.6	25	70	9125	3.908E-08
Antimony, Dissolved	9.00E-06	0.050	48	2.6	25	70	9125	2.198E-09
Bromodichloromethane	2.30E-05	0.050	48	2.6	25	70	9125	5.617E-09
Dibromochloromethane	1.50E-06	0.050	48	2.6	25	70	9125	3.663E-10
Dibenzofuran	5.00E-06	0.050	48	2.6	25	70	9125	1.221E-09
1,4-Dichlorobenzene	2.00E-06	0.050	48	2.6	25	70	9125	4.885E-10
Styrene	6.50E-03	0.050	48	2.6	25	70	9125	1.587E-06
Carbon Tetrachloride	1.00E-05	0.050	48	2.6	25	70	9125	2.442E-09

TABLE P-30 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	1.60E-04	0.050	48	2.6	15	27	5475	1.013E-07
Antimony, Dissolved	9.00E-06	0.050	48	2.6	15	27	5475	5.699E-09
Bromodichloromethane	2.30E-05	0.050	48	2.6	15	27	5475	1.456E-08
Dibromochloromethane	1.50E-06	0.050	48	2.6	15	27	5475	9.498E-10
Dibenzofuran	5.00E-06	0.050	48	2.6	15	27	5475	3.166E-09
1,4-Dichlorobenzene	2.00E-06	0.050	48	2.6	15	27	5475	1.266E-09
Styrene	6.50E-03	0.050	48	2.6	15	27	5475	4.116E-06
Carbon Tetrachloride	1.00E-05	0.050	48	2.6	15	27	5475	6.332E-09

TABLE P-31 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	1.60E-04	0.050	48	2.6	25	70	25550	1.396E-08
Antimony, Dissolved	9.00E-06	0.050	48	2.6	25	70	25550	7.850E-10
Bromodichloromethane	2.30E-05	0.050	48	2.6	25	70	25550	2.006E-09
Dibromochloromethane	1.50E-06	0.050	48	2.6	25	70	25550	1.308E-10
Dibenzofuran	5.00E-06	0.050	48	2.6	25	70	25550	4.361E-10
1,4-Dichlorobenzene	2.00E-06	0.050	48	2.6	25	70	25550	1.744E-10
Styrene	6.50E-03	0.050	48	2.6	25	70	25550	5.670E-07
Carbon Tetrachloride	1.00E-05	0.050	48	2.6	25	70	25550	8.722E-10

TABLE P-32 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Benzene	1.60E-04	0.050	48	2.6	15	27	25550	2.171E-08
Antimony, Dissolved	9.00E-06	0.050	48	2.6	15	27	25550	1.221E-09
Bromodichloromethane	2.30E-05	0.050	48	2.6	15	27	25550	3.121E-09
Dibromochloromethane	1.50E-06	0.050	48	2.6	15	27	25550	2.035E-10
Dibenzofuran	5.00E-06	0.050	48	2.6	15	27	25550	6.784E-10
1,4-Dichlorobenzene	2.00E-06	0.050	48	2.6	15	27	25550	2.714E-10
Styrene	6.50E-03	0.050	48	2.6	15	27	25550	8.819E-07
Carbon Tetrachloride	1.00E-05	0.050	48	2.6	15	27	25550	1.357E-09

TABLE P-33 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH THUNDERBAY RIVER SURFACE WATER
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	2.6	2.6
Dermal Permeability Constant	0.00084	0.00084
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	

TABLE P-34 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	1.600E-04	0.1	19400	48	2.6	25	70	9125	0.001	1.516E-06
Antimony, Dissolved	9.000E-06	0.001	19400	48	2.6	25	70	9125	0.001	8.528E-10
Bromodichloromethane	2.300E-05	0.0058	19400	48	2.6	25	70	9125	0.001	1.264E-08
Dibromochloromethane	1.500E-06	0.0039	19400	48	2.6	25	70	9125	0.001	5.543E-10
Dibenzofuran	5.000E-06	0.00084	19400	48	2.6	25	70	9125	0.001	3.980E-10
1,4-Dichlorobenzene	2.000E-06	0.062	19400	48	2.6	25	70	9125	0.001	1.175E-08
Styrene	6.500E-03	0.00084	19400	48	2.6	25	70	9125	0.001	5.174E-07
Carbon Tetrachloride	1.000E-05	0.022	19400	48	2.6	25	70	9125	0.001	2.085E-08

TABLE P-35 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	1.600E-04	0.1	13300	48	2.6	15	27	5475	0.001	2.695E-06
Antimony, Dissolved	9.000E-06	0.001	13300	48	2.6	15	27	5475	0.001	1.516E-09
Bromodichloromethane	2.300E-05	0.0058	13300	48	2.6	15	27	5475	0.001	2.247E-08
Dibromochloromethane	1.500E-06	0.0039	13300	48	2.6	15	27	5475	0.001	9.853E-10
Dibenzofuran	5.000E-06	0.00084	13300	48	2.6	15	27	5475	0.001	7.074E-10
1,4-Dichlorobenzene	2.000E-06	0.062	13300	48	2.6	15	27	5475	0.001	2.088E-08
Styrene	6.500E-03	0.00084	13300	48	2.6	15	27	5475	0.001	9.196E-07
Carbon Tetrachloride	1.000E-05	0.022	13300	48	2.6	15	27	5475	0.001	3.705E-08

TABLE P-36 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	1.600E-04	0.1	19400	48	2.6	25	70	25550	0.001	5.415E-07
Antimony, Dissolved	9.000E-06	0.001	19400	48	2.6	25	70	25550	0.001	3.046E-10
Bromodichloromethane	2.300E-05	0.0058	19400	48	2.6	25	70	25550	0.001	4.515E-09
Dibromochloromethane	1.500E-06	0.0039	19400	48	2.6	25	70	25550	0.001	1.980E-10
Dibenzofuran	5.000E-06	0.00084	19400	48	2.6	25	70	25550	0.001	1.421E-10
1,4-Dichlorobenzene	2.000E-06	0.062	19400	48	2.6	25	70	25550	0.001	4.197E-09
Styrene	6.500E-03	0.00084	19400	48	2.6	25	70	25550	0.001	1.848E-07
Carbon Tetrachloride	1.000E-05	0.022	19400	48	2.6	25	70	25550	0.001	7.445E-09

TABLE P-37 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Benzene	1.600E-04	0.1	13300	48	2.6	15	27	25550	0.001	5.775E-07
Antimony, Dissolved	9.000E-06	0.001	13300	48	2.6	15	27	25550	0.001	3.248E-10
Bromodichloromethane	2.300E-05	0.0058	13300	48	2.6	15	27	25550	0.001	4.815E-09
Dibromochloromethane	1.500E-06	0.0039	13300	48	2.6	15	27	25550	0.001	2.111E-10
Dibenzofuran	5.000E-06	0.00084	13300	48	2.6	15	27	25550	0.001	1.516E-10
1,4-Dichlorobenzene	2.000E-06	0.062	13300	48	2.6	15	27	25550	0.001	4.475E-09
Styrene	6.500E-03	0.00084	13300	48	2.6	15	27	25550	0.001	1.971E-07
Carbon Tetrachloride	1.000E-05	0.022	13300	48	2.6	15	27	25550	0.001	7.940E-09

TABLE P-38 EXPOSURE ASSESSMENT PARAMETERS - SOIL INHALATION
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Inhalation Rate, (mg/cu m)	20
Exposure Time (hours/day)	8
Exposure Frequency (days/year)	250
Exposure Duration (years)	0.08
Body Weight (kilograms)	70
Averaging Time (years)	
Carcinogens	70
Noncarcinogens	0.08

TABLE P-39 DAILY INTAKE - ADULT
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Chlorobenzene	5.166E-02	0.08	20	8	250	70	29.2	8.087E-02
Ethylbenzene	3.912E-02	0.08	20	8	250	70	29.2	6.124E-02
Styrene	3.460E-02	0.08	20	8	250	70	29.2	5.416E-02

TABLE P-40 DAILY INTAKE - ADULT
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Chlorobenzene	5.166E-02	0.08	20	8	250	70	25550	9.243E-05
Ethylbenzene	3.912E-02	0.08	20	8	250	70	25550	6.998E-05
Styrene	3.460E-02	0.08	20	8	250	70	25550	6.190E-05

TABLE P-41 SOIL INHALATION MODEL CALCULATIONS
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Soil Density	1.257	g/cm^3	78.46 lb/ft^3
Pile soil area	6550 ft^2		6090000
Length in wind direction	100 ft		3048 cm
Width across wind direction	62.5 ft		1905 cm
Total depth of soil	1 ft		30.48 cm
Wind Velocity	353 cm/sec		
Gas Constant	62300 mm hg-cm^3/mol-k		
Ambient Temperature	293 K		

Computations	Chlorobenzene	Ethylbenzene	Styrene
C(i), mg/kg	3.1163170E+03	3.9703610E+03	3.9202323E+03
W(i)/W, g/g	0.0311631697	0.0397036102	0.0392023234
W(i), g	7271251.3532943	9263978.3493339	9147013.9211972
W(v,i), g/cm			
D(i), cm^2/sec	0.075	0.0658	0.077
M(i), g/mol	112.56	106.16	104.16
p(i) @293K, mm Hg	8.75	7.5	6.25
F(V), dimensionless	0.9	0.9	0.9
Initial Values, no soil cap			
E(i,j), g/sec	3.47E+01	2.63E+01	2.33E+01
C(air,i,j), mg/m^3)	2.58E-02	1.96E-02	1.73E-02
Time (i,j), hr	1.91E+00	3.21E+00	3.58E+00

TABLE P-42 SOIL INHALATION MODEL CALCULATIONS
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Soil Density	1.257	g/cm^3		78.46	lb/ft^3
Excavated soil area	5900	ft^2		5400000	cm
Length in wind direction	100	ft		3048	cm
Width across wind direction	50	ft		1524	cm
Total depth of soil	1	ft		30.48	cm
Wind Velocity	353	cm/sec			
Gas Constant	62300	mm hg-cm^3/mol-k			
Ambient Temperature	293	K			
Computations	Chlorobenzene		Ethylbenzene	Styrene	
C(i), mg/kg	3116.31697		3970.36102	3920.23234	
W(i)/W, g/g	0.0311631697		0.0397036102	0.0392023234	
W(i), g	6447414.9930688		8214365.0388183	8110652.7380074	
W(v,i), g/cm					
D(i), cm^2/sec	0.075		0.0658	0.077	
M(i), g/mol	112.56		106.16	104.16	
p(i) @293K, mm Hg	8.75		7.5	6.25	
F(V), dimensionless	0.9		0.9	0.9	
Initial Values, no soil cap					
E(i,j), g/sec	2.78E+01		2.10E+01	1.86E+01	
C(air,i,j), mg/m^3)	2.58E-02		1.96E-02	1.73E-02	
Time (i,j), hr	2.11E+00		3.56E+00	3.97E+00	

TABLE P-43 CANCER ESTIMATE - GROUNDWATER INGESTION SHALLOW AQUIFER PRODUCTION WELL
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Benzene	2.249E-06	5.636E-07	NO	0.029	A	Leukemia	IRIS 93	7E-08		2E-08	
Antimony, Dissolved	1.166E-05	2.922E-06	NO	NO EVIDENCE				0E+00		0E+00	
Bromodichloromethane	7.498E-08	1.879E-08	NO	0.062	B2	Liver	IRIS 93	5E-09		1E-09	
Dibromochloromethane	2.166E-07	5.427E-08	NO	NO EVIDENCE				0E+00		0E+00	
Dibenzofuran	4.166E-08	1.044E-08	NO	NO EVIDENCE				0E+00		0E+00	
1,4-Dichlorobenzene	1.250E-08	3.131E-09	NO	0.024	C	Liver tumors	HEAST FY93	3E-10		8E-11	
Styrene	2.166E-08	5.427E-09	NO	NO EVIDENCE				0E+00		0E+00	
Carbon Tetrachloride	9.997E-06	2.505E-06	NO	0.13	B2	Heptocellular carcinomas		1E-06		3E-07	
Total									1E-06		3E-07

TABLE P-44 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INGESTION SHALLOW AQUIFER PRODUCTION WELL FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Benzene	6.298E-06	2.630E-06	NO	NO DATA	NA	NA	NA				
Antimony, Dissolved	3.266E-05	1.364E-05	NO	0.0004	Reduced lifespan	IRIS 93		8E-02		3E-02	
Bromodichloromethane	2.099E-07	8.767E-08	NO	0.02	Renal cytomegaly	IRIS 93	1	1E-05		4E-06	
Dibromochloromethane	1.166E-07	2.533E-07	NO	0.02	Hepatic lesions	IRIS 93	1	6E-06		1E-05	
Dibenzofuran	1.166E-07	4.871E-08	NO	NO DATA	NA	NA	NA				
1,4-Dichlorobenzene	3.499E-08	1.461E-08	NO	NO DATA	NA	NA	NA				
Styrene	6.065E-08	2.533E-08	NO	0.2	Hepatotoxicity	IRIS 93	1	3E-07		1E-07	
Carbon Tetrachloride	2.799E-05	1.169E-05	NO	0.0007	Liver Lesions	IRIS 93	1	4E-02		2E-02	
Total									1E-01		5E-02

TABLE P-45 CANCER ESTIMATE - GROUNDWATER INHALATION SHALLOW AQUIFER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Benzene	7.649E-07	1.917E-07	NO	0.029	A	Leukemia	IRIS, 1993	2E-08		6E-09	
Antimony, Dissolved	0.000E+00	0.000E+00	NO	NO EVIDENCE				0E+00		0E+00	
Bromodichloromethane	2.550E-08	6.389E-09	NO	0.062	B2	NA (1)	IRIS, 1993	2E-09		4E-10	
Dibromochloromethane	7.366E-08	1.846E-08	NO	0.084	C	NA (1)	IRIS, 1993	6E-09		2E-09	
Dibenzofuran	0.000E+00	0.000E+00	NO	NO DATA				0E+00		0E+00	
1,4-Dichlorobenzene	4.250E-09	1.065E-09	NO	0.04	C	NA	IRIS, 1993	2E-10		4E-11	
Styrene	7.366E-09	1.846E-09	NO	NO EVIDENCE				0E+00		0E+00	
Carbon Tetrachloride	3.400E-06	8.518E-07	NO	0.053	B2	Carcinogenicity (rat, mouse, hamster)	IRIS, 1993	2E-07	2E-07	5E-08	5E-08

(1) Oral slope factor was used.

TABLE P-46 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INHALATION SHALLOW AQUIFER FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Benzene	2.142E-06	8.944E-07	NO	NO DATA	NA	IRIS, chronic oral RfD used	NA				
Antimony, Dissolved	0.000E+00	0.000E+00	NO	0.0004	NA	IRIS, chronic oral RfD used	NA	0E+00		0E+00	
Bromodichloromethane	7.139E-08	2.981E-08	NO	0.02	NA	IRIS, chronic oral RfD used	NA	4E-06		1E-06	
Dibromochloromethane	2.062E-07	8.613E-08	NO	0.02	NA	IRIS, chronic oral RfD used	NA	1E-05		4E-06	
Dibenzofuran	0.000E+00	0.000E+00	NO	NA	NA	IRIS, chronic oral RfD used	NA				
1,4-Dichlorobenzene	1.190E-08	4.969E-09	NO	0.2	Liver, Kidney	HEAST 93	NA	6E-08		2E-08	
Styrene	2.062E-08	8.613E-09	NO	1	NA	IRIS, chronic oral RfD used	NA	2E-08		9E-09	
Carbon Tetrachloride	9.519E-06	3.975E-06	NO	0.0007	NA	IRIS, chronic oral RfD used	NA	1E-02		6E-03	
Total									1E-02		6E-03

TABLE P-47 CANCER ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Benzene	5.455E-07	9.370E-08	YES	2.90E-02	A	Leukemia	IRIS 93	2E-08		3E-09	
Antimony, Dissolved	2.828E-08	4.858E-09	YES	NO EVIDENCE				0E+00		0E+00	
Bromodichloromethane	1.055E-09	1.812E-10	YES	6.33E-02	B2	Liver	IRIS 93	7E-11		1E-11	
Dibromochloromethane	2.049E-09	3.519E-10	YES	NO EVIDENCE				0E+00		0E+00	
Dibenzofuran	8.485E-11	1.458E-11	YES	NO EVIDENCE				0E+00		0E+00	
1,4-Dichlorobenzene	1.879E-09	3.227E-10	YES	2.40E-02	C	Liver tumors	HEAST FY93	5E-11		8E-12	
Styrene	4.412E-11	7.579E-12	YES	NO EVIDENCE				0E+00		0E+00	
Carbon Tetrachloride	5.334E-07	9.162E-08	YES	1.30E-01	B2	Heptocellular carcinomas		7E-08		1E-08	
Total									9E-08		1E-08

*Adjusted from administered to absorbed dose using an oral absorption efficiency factor. Benzene =1,Bromodichlormehane = 0.98, 1,4 DCB=1, CCl4=.05,

TABLE P-48 CHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source		Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Benzene	1.527E-06	4.373E-07	YES	NO DATA	NA	NA	NA					
Antimony, Dissolved	7.919E-08	2.267E-08	YES	2E-05	Reduced lifespan	IRIS 93			4E-03		1E-03	
Bromodichloromethane	2.953E-09	8.454E-10	YES	0.0196	Renal cytomegaly	IRIS 93		1	2E-07		4E-08	
Dibromochloromethane	5.736E-09	1.642E-09	YES	0.02	Hepatic lesions	IRIS 93		1	3E-07		8E-08	
Dibenzofuran	2.376E-10	6.802E-11	YES	NO DATA	NA	NA	NA					
1,4-Dichlorobenzene	5.261E-09	1.506E-09	YES	NO DATA	NA	NA	NA					
Styrene	1.235E-10	3.537E-11	YES	0.01	Hepatotoxicity	IRIS 93		1	1E-08		4E-09	
Carbon Tetrachloride	1.493E-06	4.275E-07	YES	3.5E-05	Liver Lesions	IRIS 93		1	4E-02		1E-02	
Total										5E-02		1E-02

TABLE P-49 CANCER ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - ADULTS

Carcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Chemical-Specific Risk	Total Pathway Risk
Chlorobenzene	7.529E-08	YES	NO EVIDENCE				0E+00	
Ethylbenzene	9.593E-08	YES	NO EVIDENCE				0E+00	
Styrene	9.472E-08	YES	NO EVIDENCE*				0E+00	
Total								0E+00

*Styrene classified as possible human carcinogen by IRAC. No slope factor has been adopted as of 12/08/93.

TABLE P-60 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - ADULTS

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Chemical-Specific Risk	Total Pathway Risk
Chlorobenzene	6.588E-05	YES	0.01	Liver	HEAST FY93	1	7E-03	
Ethylbenzene	8.394E-05	YES	0.085	Liver and Kidney	HEAST FY93	1	1E-03	
Styrene	8.288E-05	YES	0.01	Liver	IRIS 93	1	8E-03	
Total								2E-02

*RfD adjusted from administered to absorbed dose using an absorption efficiency of 5%, unless a chemical specific efficiency was available. Ethylbenzene 85% efficiency used.

TABLE P-51 CANCER ESTIMATE - SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Carcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Chemical-Specific Risk	Total Pathway Risk
Chlorobenzene	1.673E-05	NO	NO EVIDENCE				0E+00	
Ethylbenzene	2.131E-05	NO	NO EVIDENCE				0E+00	
Styrene	2.104E-05	NO	NO EVIDENCE(1)				0E+00	
Total								0E+00

(1) Classified by IRAC as possible human carcinogen. No SF has been adopted as of 12/08/93.

TABLE P-52 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Chemical-Specific Risk	Total Pathway Risk
Chlorobenzene	1.67E-05	NO	0.2	Liver	HEAST FY93	1	8E-05	
Ethylbenzene	2.13E-05	NO	1	Liver and Kidney	HEAST FY93	1	2E-05	
Styrene	2.10E-05	NO	0.2	Red Blood Cell, Liver	IRIS 93	1	1E-04	
Total								2E-04

No subchronic RfD available as of 12/08/93. Chronic RfD used.

TABLE P-53 CANCER ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
								0E+00		0E+00	
Benzene	3.77E-08	4.67E-08	NO	0.029	A	Leukemia	IRIS 93	1E-09		1E-09	
Antimony, Dissolved	8.83E-11	1.09E-10	NO	NO EVIDENCE				0E+00		0E+00	
Bromodichloromethane	6.77E-09	8.39E-09	NO	0.062	B2	Liver	IRIS 93	4E-10		5E-10	
Dibromochloromethane	3.39E-10	4.19E-10	NO	NO EVIDENCE				0E+00		0E+00	
Dibenzofuran	4.91E-11	6.08E-11	NO	NO EVIDENCE				0E+00		0E+00	
1,4-Dichlorobenzene	1.18E-09	1.46E-09	NO	0.024	C	Liver tumors	HEAST FY93	3E-11		4E-11	
Styrene	6.38E-06	7.90E-06	NO	NO EVIDENCE				0E+00		0E+00	
Carbon Tetrachloride	9.81E-11	1.22E-10	NO	0.13	B2	Heptocellular carcinomas		1E-11		2E-11	
Total									2E-09		2E-09

TABLE P-54 CHRONIC HAZARDOUS INDEX ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Benzene	1.06E-07	2.18E-07	NO	NO DATA	NA	NA	NA				
Antimony, Dissolved	2.47E-10	5.11E-10	NO	0.0004	Reduced lifespan	IRIS 93		6E-07		1E-06	
Bromodichloromethane	1.90E-08	3.91E-08	NO	0.02	Renal cytomegaly	IRIS 93	1	9E-07		2E-06	
Dibromochloromethane	9.48E-10	1.96E-09	NO	0.02	Hepatic lesions	IRIS 93	1	5E-08		1E-07	
Dibenzofuran	1.37E-10	2.84E-10	NO	NO DATA	NA	NA	NA				
1,4-Dichlorobenzene	3.30E-09	6.81E-09	NO	NO DATA	NA	NA	NA				
Styrene	1.79E-05	3.69E-05	NO	0.2	Hepatotoxicity	IRIS 93	1	9E-05		2E-04	
Carbon Tetrachloride	2.75E-10	5.67E-10	NO	0.0007	Liver Lesions	IRIS 93	1	4E-07		8E-07	
Total									9E-05		2E-04

TABLE P-55 CANCER ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
								0E+00		0E+00	
Benzene	1.396E-08	2.171E-08	NO	0.029	A	Leukemia	IRIS 93	4E-10		6E-10	
Antimony, Dissolved	7.850E-10	1.221E-09	NO	NO EVIDENCE				0E+00		0E+00	
Bromodichloromethane	2.006E-09	3.121E-09	NO	0.062	B2	Liver	IRIS 93	1E-10		2E-10	
Dibromochloromethane	1.308E-10	2.035E-10	NO	NO EVIDENCE				0E+00		0E+00	
Dibenzofuran	4.361E-10	6.784E-10	NO	NO EVIDENCE				0E+00		0E+00	
1,4-Dichlorobenzene	1.744E-10	2.714E-10	NO	0.024	C	Liver tumors	HEAST FY93	4E-12		7E-12	
Styrene	5.670E-07	8.819E-07	NO	NO EVIDENCE				0E+00		0E+00	
Carbon Tetrachloride	8.722E-10	1.357E-09	NO	0.13	B2	Heptocellular carcinomas		1E-10		2E-10	
Total									6E-10		1E-09

TABLE P-6a CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Benzene	3.908E-08	1.013E-07	NO	NO DATA	NA	NA	NA				
Antimony, Dissolved	2.198E-09	5.699E-09	NO	0.0004	Reduced lifespan	IRIS 93		5E-06		1E-05	
Bromodichloromethane	5.617E-09	1.456E-08	NO	0.02	Renal cytomegaly	IRIS 93	1	3E-07		7E-07	
Dibromochloromethane	3.663E-10	9.498E-10	NO	0.02	Hepatic lesions	IRIS 93	1	2E-08		5E-08	
Dibenzofuran	1.221E-09	3.166E-09	NO	NO DATA	NA	NA	NA				
1,4-Dichlorobenzene	4.885E-10	1.266E-09	NO	NO DATA	NA	NA	NA				
Styrene	1.587E-06	4.116E-06	NO	0.2	Hepatotoxicity	IRIS 93	1	8E-06		2E-05	
Carbon Tetrachloride	2.442E-09	6.332E-09	NO	0.0007	Liver Lesions	IRIS 93	1	3E-06		9E-06	
Total									2E-05		4E-05

TABLE P-57 CANCER ESTIMATE - SURFACE WATER DERMAL
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF* (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
								0E+00		0E+00	
Benzene	5.41E-07	5.77E-07	YES	2.90E-02	A	Leukemia	IRIS 93	2E-08		2E-08	
Antimony, Dissolved	3.05E-10	3.25E-10	YES	NO EVIDENCE				0E+00		0E+00	
Bromodichloromethane	4.51E-09	4.81E-09	YES	6.33E-02	B2	Liver	IRIS 93	3E-10		3E-10	
Dibromochloromethane	1.98E-10	2.11E-10	YES	NO EVIDENCE				0E+00		0E+00	
Dibenzofuran	1.42E-10	1.52E-10	YES	NO EVIDENCE				0E+00		0E+00	
1,4-Dichlorobenzene	4.20E-09	4.48E-09	YES	2.40E-02	C	Liver tumors	HEAST FY93	1E-10		1E-10	
Styrene	1.85E-07	1.97E-07	YES	NO EVIDENCE				0E+00		0E+00	
Carbon Tetrachloride	7.45E-09	7.94E-09	YES	1.30E-01	B2	Heptocellular carcinomas		1E-09		1E-09	
Total									2E-08		2E-08

*Adjusted from administered to absorbed dose using an oral absorption efficiency factor. Benzene =1,Bromodichlormehane = 0.98, 1,4 DCB=1, CCl4=.05,

TABLE P-58 CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER DERMAL
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Benzene	1.52E-06	2.69E-06	YES	NO DATA	NA	NA	NA				
Antimony, Dissolved	8.53E-10	1.52E-09	YES	2E-05	Reduced lifespan	IRIS 93		4E-05		8E-05	
Bromodichloromethane	1.26E-08	2.25E-08	YES	0.0196	Renal cytomegaly	IRIS 93	1	6E-07		1E-06	
Dibromochloromethane	5.54E-10	9.85E-10	YES	0.02	Hepatic lesions	IRIS 93	1	3E-08		5E-08	
Dibenzofuran	3.98E-10	7.07E-10	YES	NO DATA	NA	NA	NA				
1,4-Dichlorobenzene	1.18E-08	2.09E-08	YES	NO DATA	NA	NA	NA				
Styrene	5.17E-07	9.20E-07	YES	0.01	Hepatotoxicity	IRIS 93	1	5E-05		9E-05	
Carbon Tetrachloride	2.08E-08	3.71E-08	YES	3.5E-05	Liver Lesions	IRIS 93	1	6E-04		1E-03	
Total									7E-04		1E-03

TABLE P-59 CANCER ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Carcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Excavation Worker Chemical-Specific Risk	Total Pathway Risk
Chlorobenzene	9.243E-05	NO	NO EVIDENCE				0E+00	
Ethylbenzene	6.998E-05	NO	NO EVIDENCE				0E+00	
Styrene	6.190E-05	NO	NO EVIDENCE*				0E+00	
Total								0E+00

* Styrene classified as possible human carcinogen by IRAC. No slope factor has been adopted as of 12/08/93.

TABLE P-60 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Noncarcinogenic Effects
Site 1, Former POL Facility, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Excavation Worker Chemical-Specific Risk	Total Pathway Risk
Chlorobenzene	8.087E-02	NO	0.05	Liver and Kidney	Heast FY93	1	2E+00	
Ethylbenzene	6.124E-02		0.29	Developmental Toxicity	Heast FY93	1	2E-01	
Styrene	5.416E-02		0.91	CNS effects	Heast FY93	1	6E-02	
Total								2E+00

* RfD converted from corresponding RfC values.

Groundwater Solute Transport Model Data - Site 1

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.

2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.

3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.

4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer-properties.

5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.

6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft^2/day at TF4-MW3 to 15,290 ft^2/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^{n} (h_m - h_s)_i^2]^{0.5}$$

n = number of wells
h_m = measured head
h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = 128.78/38 = 3.3891
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

* The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).

* The initial head data input to the transport model are results of measurements taken in September 1993.

* Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.

* Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.

* The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.

* The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 1

The following compounds were present at Site 1: Benzene, Bromodichloromethane, Dibromochloromethane, 1,4- Dichlorobenzene, Styrene, Antimony, Carbon Tetrachloride, and Dibenzofuran. Concentrations input to the model are the result of groundwater sampling conducted during the July to September 1993 RI field events.

For Site 1, several scenarios were modeled. These included monitoring chemical concentrations through time along the South Branch of the Thunder Bay River and at Production Well #3 for chemicals observed in several wells at Site 1. Wells S1MW14, S1MW11, S1MW6, and Production Well #3 all had chemicals present above MDNR Type A or B cleanup criteria.

The following scenarios were modeled for S1MW14: Benzene at 11.5 ug/l, Bromodichloromethane at 0.78 ug/l, Dibromochlormethane at 2.1 ug/l, 1,4 - Dichlorobenzene at 0.08 ug/l, and Styrene at a concentration of 0.13 ug/l. Concentrations were input to the node corresponding to S1MW14 and concentrations through time were monitored along the South Branch of the Thunder Bay River.

Wells S1MW11 and S1MW6 contained elevated levels of Antimony at a concentration of 39.2 ug/l. This concentration was input to the model and the corresponding concentrations of Antimony through time were monitored along the South Branch of the Thunder Bay River.

Additionally, Carbon Tetrachloride and Dibenzofuran were present in Production Well #3 at concentrations of 1.2 ug/l and 2.5 ug/l, respectively. These values were input to the model and the concentrations were monitored through time along the South Branch of the Thunder Bay River.

Appendix Q: Site 2 Risk Assessment

Table Q-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 2
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-MP2	MW1	PC-MP2-MW1-GW4	GROUNDWATER	Arsenic, Dissolved	7.2000
PC-MP2	MW3	PC-MP2-MW3-GW4	GROUNDWATER	Arsenic, Dissolved	2.0000
PC-MP2	MW4	PC-MP2-MW4-GW4	GROUNDWATER	Arsenic, Dissolved	2.0000
PC-MP2	MW5	PC-MP2-MW5-GW4	GROUNDWATER	Arsenic, Dissolved	5.0500
PC-MP2	MW6	PC-MP2-MW6-GW4	GROUNDWATER	Arsenic, Dissolved	2.0000
PC-MP2	MW7	PC-MP2-MW7-GW4	GROUNDWATER	Arsenic, Dissolved	2.0000
PC-MP2	MW1	PC-MP2-MW1-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-MP2	MW2	PC-MP2-MW2-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-MP2	MW3	PC-MP2-MW3-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-MP2	MW4	PC-MP2-MW4-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-MP2	MW5	PC-MP2-MW5-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-MP2	MW6	PC-MP2-MW6-GW4	GROUNDWATER	Tetrachloroethylene	0.1200
PC-MP2	MW7	PC-MP2-MW7-GW4	GROUNDWATER	Tetrachloroethylene	6.3000

Table Q-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Soil - Site 2
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE		RESULT
PC-MP2	SB10	PC-MP2-SB10-SS00-01	SOIL	Lead	0.0000	1.0000	1.3000
PC-MP2	SB6	PC-MP2-SB6-SS00-02	SOIL	Lead	0.0000	2.0000	31.0000

TABLE Q-1 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF GROUNDWATER
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Ingestion Rate (L/day)	2	2
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE Q-2 DAILY INTAKE - ADULT
INGESTION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	4.613E-03	2	298	25	70	9125	1.076E-04
Tetrachloroethylene	2.737E-03	2	298	25	70	9125	6.384E-05

TABLE Q-3 DAILY INTAKE - CHILD
INGESTION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	4.613E-03	2	48	15	27	5475	4.494E-05
Tetrachloroethylene	2.737E-03	2	48	15	27	5475	2.666E-05

TABLE Q-4 DAILY INTAKE - ADULT
INGESTION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	4.613E-03	2	298	25	70	25550	3.843E-05
Tetrachloroethylene	2.737E-03	2	298	25	70	25550	2.280E-05

TABLE Q-5 DAILY INTAKE - CHILD
INGESTION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	4.613E-03	2	48	15	27	25550	9.629E-06
Tetrachloroethylene	2.737E-03	2	48	15	27	25550	5.712E-06

TABLE Q-6 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	9.000E-04	2	298	25	70	9125	2.099E-05
Tetrachloroethylene	1.000E-05	2	298	25	70	9125	2.333E-07

TABLE Q-7 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	9.000E-04	2	48	15	27	5475	8.767E-06
Tetrachloroethylene	1.000E-05	2	48	15	27	5475	9.741E-08

TABLE Q-8 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	9.000E-04	2	298	25	70	25550	7.498E-06
Tetrachloroethylene	1.000E-05	2	298	25	70	25550	8.331E-08

TABLE Q-9 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	9.000E-04	2	48	15	27	25550	1.879E-06
Tetrachloroethylene	1.000E-05	2	48	15	27	25550	2.087E-08

TABLE Q-10 EXPOSURE ASSESSMENT PARAMETERS - INHALATION OF GROUNDWATER
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Exposure Time (hours/day)	0.12	0.12
Inhalation Rate (cu m/hr)	0.6	0.6
Exposure Frequency (days/yr)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE Q-11 DAILY INTAKE - ADULT
INHALATION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.6	298	0.12	25	70	9125	0.000E+00
Tetrachloroethylene	2.585E-02	0.6	298	0.12	25	70	9125	2.171E-05

TABLE Q-12 DAILY INTAKE - CHILD
INHALATION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.600	48	0.12	15	27	5475	0.000E+00
Tetrachloroethylene	2.585E-02	0.600	48	0.12	15	27	5475	9.065E-06

TABLE Q-13 DAILY INTAKE - ADULT
INHALATION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.6	298	0.12	25	70	25550	0.000E+00
Tetrachloroethylene	2.585E-02	0.6	298	0.12	25	70	25550	7.753E-06

TABLE Q-14 DAILY INTAKE - CHILD
INHALATION OF SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.600	48	0.12	15	27	25550	0.000E+00
Tetrachloroethylene	2.585E-02	0.600	48	0.12	15	27	25550	1.943E-06

TABLE Q-15 DAILY INTAKE - ADULT
INHALATION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.6	298	0.12	25	70	9125	0.000E+00
Tetrachloroethylene	9.446E-05	0.6	298	0.12	25	70	9125	7.932E-08

TABLE Q-16 DAILY INTAKE - CHILD
INHALATION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0	0.600	48	0.12	15	27	5475	0.000E+00
Tetrachloroethylene	9.446023E-05	0.600	48	0.12	15	27	5475	3.313E-08

TABLE Q-17 DAILY INTAKE - ADULT
INHALATION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.6	298	0.12	25	70	25550	0.000E+00
Tetrachloroethylene	9.446E-05	0.6	298	0.12	25	70	25550	2.833E-08

TABLE Q-18 DAILY INTAKE - CHILD
INHALATION OF GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	0.000E+00	0.600	48	0.12	15	27	25550	0.000E+00
Tetrachloroethylene	9.446E-05	0.600	48	0.12	15	27	25550	7.098E-09

TABLE Q-19 GROUNDWATER INHALATION MODEL CALCULATIONS
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemicals	Chemical Concentration (mg/L)	Fraction Volatilized (unitless)	Water Flow Rate (L/hr)	Showering Duration Period (hr)	Post Showering Duration Period (hr)	Bathroom Volume (cu m)	Showering Maximum Contaminant Concn'n in Air (mg/cu m)	During and After Showering MAX Contaminant Concn'n in Air (mg/cu m)
Arsenic, Dissolved	0.000E+00	0.7	750	0.25	0.35	11	0.000E+00	0.000E+00
Tetrachloroethylene	2.737E-03	0.7	750	0.25	0.35	11	3.265E-02	2.585E-02
Future land-use - Deep Aquifer								
Arsenic, Dissolved	0.000E+00	0.7	750	0.25	0.35	11	0.000E+00	0.000E+00
Tetrachloroethylene	1.000E-05	0.7	750	0.25	0.35	11	1.193E-04	9.446E-05

TABLE Q-20 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH GROUNDWATER
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	0.25	0.25
Dermal Permeability Constant	*	*
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	

* Chemical Specific Dermal Permeability Constant

TABLE Q-21 DAILY INTAKE - ADULT
SHALLOW GROUNDWATER DERMAL CONTACT
CURRENT LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(a)	4.613E-03	0.003	19400	298	0.25	25	70	9125	0.001	7.828E-07
Tetrachloroethylene	(b)	2.737E-03	0.4	19400	298	0.25	25	70	9125	0.001	6.192E-05

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(b) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

TABLE Q-22 DAILY INTAKE - CHILD
SHALLOW GROUNDWATER DERMAL CONTACT
CURRENT LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(a)	4.613E-03	0.003	13300	48	0.25	15	27	5475	0.001	2.241E-07
Tetrachloroethylene	(b)	2.737E-03	0.4	13300	48	0.25	15	27	5475	0.001	1.773E-05

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(b) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

TABLE Q-23 DAILY INTAKE - ADULT
SHALLOW GROUNDWATER DERMAL CONTACT
CURRENT LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(a)	4.613E-03	0.003	19400	298	0.25	25	70	25550	0.001	2.796E-07
Tetrachloroethylene	(b)	2.737E-03	0.4	19400	298	0.25	25	70	25550	0.001	2.211E-05

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(b) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

TABLE Q-24 DAILY INTAKE - CHILD
SHALLOW GROUNDWATER DERMAL CONTACT
CURRENT LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(a)	4.613E-03	0.003	13300	48	0.25	15	27	25550	0.001	4.803E-08
Tetrachloroethylene	(b)	2.737E-03	0.4	13300	48	0.25	15	27	25550	0.001	3.799E-06

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(b) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

TABLE Q-25 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(c)	9.000E-04	0.001	19400	298	0.25	25	70	9125	0.001	5.091E-08
Tetrachloroethylene	(a)	1.000E-05	0.4	19400	298	0.25	25	70	9125	0.001	2.263E-07

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental of predicted PC values (Tables 5-3 of U. S. EPA, 1992a).

TABLE Q-26 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(c)	9.000E-04	0.001	13300	48	0.25	15	27	5475	0.001	1.458E-08
Tetrachloroethylene	(a)	1.000E-05	0.4	13300	48	0.25	15	27	5475	0.001	6.478E-08

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental of predicted PC values (Tables 5-3 of U. S. EPA, 1992a).

TABLE Q-27 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(c)	9.000E-04	0.001	19400	298	0.25	25	70	25550	0.001	1.818E-08
Tetrachloroethylene	(a)	1.000E-05	0.4	19400	298	0.25	25	70	25550	0.001	8.081E-08

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental of predicted PC values (Tables 5-3 of U. S. EPA, 1992a).

TABLE Q-28 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 2, Motor Pool, Alpena CRTC, Alpena MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Arsenic, Dissolved	(c)	9.000E-04	0.001	13300	48	0.25	15	27	25550	0.001	3.123E-09
Tetrachloroethylene	(a)	1.000E-05	0.4	13300	48	0.25	15	27	25550	0.001	1.388E-08

(a) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental of predicted PC values (Tables 5-3 of U. S. EPA, 1992a).

TABLE Q-29 CANCER ESTIMATE - SHALLOW GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical		Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved		3.843E-05	9.629E-06	NO	1.8	A (1)	Skin, Lung	IRIS, 93	7E-05		2E-05	
Tetrachloroethylene	(1)	2.280E-05	5.712E-06	NO	0.051	B2 (2)	Liver	CA EPA	1E-06		3E-07	
Total										7E-05		2E-05

1) Converted from a unit risk of 10-05 ug/L given in IRIS.
2) Retrieved from California EPA, 1992b.

TABLE Q-30 CHRONIC HAZARDOUS INDEX ESTIMATE - SHALLOW GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved	1.076E-04	4.494E-05	NO	0.0003	Keratosis	IRIS, 93	1	4E-01		1E-01	
Tetrachloroethylene	6.384E-05	2.666E-05	NO	0.01	Hepatoxcity	IRIS, 93	1	6E-03		3E-03	
Total									4E-01		2E-01

TABLE Q-31 CANCER ESTIMATE - GROUNDWATER INGESTION DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved	7.498E-06	1.879E-06	NO	1.8	A (1)	Skin, Lung	IRIS, 93	1E-05		3E-06	
Tetrachloroethylene	8.331E-08	2.087E-08	NO	0.051	B2 (2)	Liver	CA EPA	4E-09		1E-09	
Total									1E-05		3E-06

1) Converted from a unit risk of 10-05 ug/L given in IRIS.
2) Retrieved from California EPA, 1992b.

TABLE Q-32 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INGESTION DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved	2.099E-05	8.767E-06	NO	0.0003	Keratosis	IRIS, 93	1	7E-02		3E-02	
Tetrachloroethylene	2.333E-07	9.741E-08	NO	0.01	Hepatoxcity	IRIS, 93	1	2E-05		1E-05	
Total									7E-02		3E-02

TABLE Q-33 CANCER ESTIMATE - SHALLOW GROUNDWATER INHALATION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved	0.000E+00	0.000E+00	NO	15	A (1)	Lung, skin	IRIS 93	0E+00		0E+00	
Tetrachloroethylene	7.753E-06	1.943E-06	NO	0.0018	B2 (2)	Leukemia	CA EPA	1E-08		3E-09	
Total									1E-08		3E-09

1) Inhalation slope factor converted from inhalation unit risk.
2) Retrieved from California EPA, 1992.

TABLE Q-34 CHRONIC HAZARDOUS INDEX ESTIMATE - SHALLOW GROUNDWATER INHALATION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved	0.000E+00	0.000E+00	NO	0.0003	NA	IRIS, 93	NA	0E+00		0E+00	
Tetrachloroethylene	2.171E-05	9.065E-06	NO	0.01	NA	IRIS, 93	NA	2E-03		9E-04	
Total									2E-03		9E-04

TABLE Q-36 CANCER ESTIMATE - GROUNDWATER INHALATION DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved	0.000E+00	0.000E+00	NO	15	A (1)	Lung, skin	IRIS 93	0E+00		0E+00	
Tetrachloroethylene	2.833E-08	7.098E-09	NO	0.0018	B2 (2)	Leukemia	CA EPA	5E-11		1E-11	
Total									5E-11		1E-11

1) Inhalation slope factor converted from inhalation unit risk.
2) Retrieved from California EPA, 1992.

TABLE Q-36 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INHALATION DEEP AQUIFER PRODUCTION WELLS FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved	0.000E+00	0.000E+00	NO	0.0003	NA	IRIS, 93	NA	0E+00		0E+00	
Tetrachloroethylene	7.932E-08	3.313E-08	NO	0.01	NA	IRIS, 93	NA	8E-06		3E-06	
Total									8E-06		3E-06

TABLE Q-37 CANCER ESTIMATE - DERMAL CONTACT WITH SHALLOW GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF * (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved	2.796E-07	4.803E-08	NA	1.9	A	NA	IRIS, 93	5E-07		9E-08	
Tetrachloroethylene	2.211E-05	3.799E-06	NA	0.051	B2	NA	CA EPA	1E-06		2E-07	
									2E-06		3E-07

* Adjusted from administered to absorbed dose using an absorption efficiency of As0.95 (ATSDR, 90), PCE 1.0 (ATSDR,90)

TABLE Q-38 CHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SHALLOW GROUNDWATER FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved	7.828E-07	2.241E-07	YES	0.0003	NA	IRIS, 93	1	3E-03		7E-04	
Tetrachloroethylene	6.192E-05	1.773E-05	YES	0.01	NA	IRIS, 93	1	6E-03		2E-03	
									9E-03		3E-03

* Adjusted from administered to absorbed dose using an absorption efficiency of As0.95 (ATSDR, 90), PCE 1.0 (ATSDR,90)

TABLE Q-39 CANCER ESTIMATE - DERMAL CONTACT WITH GROUNDWATER DEEP AQUIFER PRODUCTION WELLS
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF * (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved	1.818E-08	3.123E-09	NA	1.9	A	NA	IRIS, 93	3E-08		6E-09	
Tetrachloroethylene	8.081E-08	1.388E-08	NA	0.051	B2	NA	CA EPA	4E-09		7E-10	
Total									4E-08		7E-09

* Adjusted from administered to absorbed dose using an absorption efficiency of As0.95 (ATSDR, 90), PCE 1.0 (ATSDR,90)

TABLE Q-40 CHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH GROUNDWATER DEEP AQUIFER PRODUCTION WELLS FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 2, Motor Pool, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Arsenic, Dissolved	5.091E-08	1.458E-08	YES	0.0003	NA	IRIS, 93	1	2E-04		5E-05	
Tetrachloroethylene	2.263E-07	6.478E-08	YES	0.01	NA	IRIS, 93	1	2E-05		6E-06	
Total									2E-04		6E-05

Groundwater Solute Transport Model Data - Site 2

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.

2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.

3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.

4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.

5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.

6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft^2/day at TF4-MW3 to 15,290 ft^2/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report,

Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^{n} (h_m - h_s)_i^2]^{0.5}$$

n = number of wells
h_m = measured head
h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW4_5*	8,23	676.41	676.08	0.33
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27	677.15	676.98	0.17

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = 128.78/38 = 3.3891
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

* The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).

* The initial head data input to the transport model are results of measurements taken in September 1993.

* Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.

* Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.

* The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.

* The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 2

PCE was detected in two wells at Site 2. Wells MP2MW7 and MP2MW1 contained concentrations of PCE of 6.3 and 7.2 ug/l, respectively. These concentrations were input to the model at their respective nodes and the concentrations were monitored at Production Well #2 and at the sinkhole with respect to time.

Appendix R: Site 3 Risk Assessment

Table R-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Soils and Subsoils - Site 3
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE		RESULT
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(a)anthracene	0.0000	2.0000	230.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(a)anthracene	0.0000	2.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(a)anthracene	0.0000	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Benzo(a)anthracene	4.0000	6.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Benzo(a)anthracene	10.0000	12.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Benzo(a)anthracene	4.0000	6.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Benzo(a)anthracene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Benzo(a)anthracene	4.0000	6.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Benzo(a)anthracene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Benzo(a)anthracene	8.0000	10.0000	520.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(a)pyrene	0.0000	2.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(a)pyrene	0.0000	2.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(a)pyrene	0.0000	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Benzo(a)pyrene	4.0000	6.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Benzo(a)pyrene	10.0000	12.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Benzo(a)pyrene	4.0000	6.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Benzo(a)pyrene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Benzo(a)pyrene	4.0000	6.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Benzo(a)pyrene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Benzo(a)pyrene	8.0000	10.0000	350.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	2.0000	300.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	2.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Benzo(b)fluoranthene	4.0000	6.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Benzo(b)fluoranthene	10.0000	12.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Benzo(b)fluoranthene	4.0000	6.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Benzo(b)fluoranthene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Benzo(b)fluoranthene	4.0000	6.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Benzo(b)fluoranthene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Benzo(b)fluoranthene	8.0000	10.0000	770.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	2.0000	300.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	2.0000	170.0000

Table R-1A (continued)
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Soils and Subsoils - Site 3
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE		RESULT
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Benzo(k)fluoranthene	4.0000	6.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Benzo(k)fluoranthene	10.0000	12.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Benzo(k)fluoranthene	4.0000	6.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Benzo(k)fluoranthene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Benzo(k)fluoranthene	4.0000	6.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Benzo(k)fluoranthene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Benzo(k)fluoranthene	8.0000	10.0000	770.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Chrysene	0.0000	2.0000	210.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Chrysene	0.0000	2.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Chrysene	0.0000	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Chrysene	4.0000	6.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Chrysene	10.0000	12.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Chrysene	4.0000	6.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Chrysene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Chrysene	4.0000	6.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Chrysene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Chrysene	8.0000	10.0000	530.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Dibenzofuran	0.0000	2.0000	173.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Dibenzofuran	0.0000	2.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Dibenzofuran	0.0000	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Dibenzofuran	4.0000	6.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Dibenzofuran	10.0000	12.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Dibenzofuran	4.0000	6.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Dibenzofuran	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Dibenzofuran	4.0000	6.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Dibenzofuran	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Dibenzofuran	8.0000	10.0000	150.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Indeno(1,2,3-c,d)pyrene	0.0000	2.0000	165.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Indeno(1,2,3-c,d)pyrene	0.0000	2.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Indeno(1,2,3-c,d)pyrene	0.0000	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Indeno(1,2,3-c,d)pyrene	4.0000	6.0000	170.0000

Table R-1A (continued)
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Soils and Subsoils - Site 3
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE		RESULT
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Indeno(1,2,3-c,d)pyrene	10.0000	12.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Indeno(1,2,3-c,d)pyrene	4.0000	6.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Indeno(1,2,3-c,d)pyrene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Indeno(1,2,3-c,d)pyrene	4.0000	6.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Indeno(1,2,3-c,d)pyrene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Indeno(1,2,3-c,d)pyrene	8.0000	10.0000	190.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Phenanthrene	0.0000	2.0000	305.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Phenanthrene	0.0000	2.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Phenanthrene	0.0000	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS04-06	SUBSOIL	Phenanthrene	4.0000	6.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS10-12	SUBSOIL	Phenanthrene	10.0000	12.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS04-06	SUBSOIL	Phenanthrene	4.0000	6.0000	170.0000
PC-CG3	SB12	PC-CG3-SB12-SS10-12	SUBSOIL	Phenanthrene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS04-06	SUBSOIL	Phenanthrene	4.0000	6.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS10-12	SUBSOIL	Phenanthrene	10.0000	12.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS08-10	SUBSOIL	Phenanthrene	8.0000	10.0000	1500.0000

Table R-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Surface Soils - Site 3
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE		RESULT
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(a)anthracene	0.0000	2.0000	230.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(a)anthracene	0.0000	2.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(a)anthracene	0.0000	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	2.0000	300.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	2.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(b)fluoranthene	0.0000	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	2.0000	300.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	2.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Benzo(k)fluoranthene	0.0000	2.0000	170.0000
PC-CG3	SB11	PC-CG3-SB11-SS00-02	SOIL	Chrysene	0.0000	2.0000	210.0000
PC-CG3	SB12	PC-CG3-SB12-SS00-02	SOIL	Chrysene	0.0000	2.0000	170.0000
PC-CG3	SB13	PC-CG3-SB13-SS00-02	SOIL	Chrysene	0.0000	2.0000	170.0000

TABLE R-1 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH SOILS
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Skin Surface Area Available for Contact (cm^2/day)	3120
Soil to Skin Adherence Factor (mg/cm^2)	2.77
Absorption Factor, Unitless	
Metals	0.01
Organics	0.25
Exposure Factor (days/year)	250
Exposure Duration (year)	0.08
Body Weight (kilograms)	70
Conversion Factor	1E-06
Averaging Time, years	
Carcinogens	70
Noncarcinogens	0.08

Recreational Adult Assumes that the adult works at the recreational facility 250 days /year and participates in recreational activites another 48 days per year

TABLE R-2 DAILY INTAKE - EXCAVATION WORKER
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Benzo(a)pyrene	2.210E-01	1.00E-06	3120	2.77	0.25	250	0.08	70	29.2	4.672E-06
Dibenzofuran	1.721E-01	1.00E-06	3120	2.77	0.25	250	0.08	70	29.2	3.638E-06
Phenanthrene	5.588E-01	1.00E-06	3120	2.77	0.25	250	0.08	70	29.2	1.181E-05

TABLE R-3 DAILY INTAKE - EXCAVATION WORKER
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Benzo(a)pyrene	2.210E-01	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	5.339E-09
Dibenzofuran	1.730E-01	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	4.180E-09
Phenanthrene	5.588E-01	1.0E-06	3120	2.77	0.25	250	0.08	70	25550	1.350E-08

TABLE R-4 EXPOSURE ASSESSMENT PARAMETERS - SOIL INGESTION
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Ingestion Rate (mg/day)	480
Fraction Ingested from	
Contaminated Sources (unitless)	1
Exposure Frequency (days/year)	250
Exposure Duration (years)	0.08
Body Weight (kilograms)	70
Conversion Factor	1E-06
Averaging Time, years	
Carcinogens	70
Noncarcinogens	0.08

TABLE R-5 DAILY INTAKE
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Benzo(a)pyrene	0.220994	1E-06	480	1	250	0.08	70	29.2	1.038E-06
Dibenzofuran	0.173	1E-06	480	1	250	0.08	70	29.2	8.125E-07
Phenanthrene	0.55879078	1E-06	480	1	250	0.08	70	29.2	2.624E-06

TABLE R-6 DAILY INTAKE
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Benzo(a)pyrene	0.220994	1E-06	480	1	250	0.08	70	25550	1.186E-09
Dibenzofuran	0.173	1E-06	480	1	250	0.08	70	25550	9.286E-10
Phenanthrene	0.55879078	1E-06	480	1	250	0.08	70	25550	2.999E-09

TABLE R-7 EXPOSURE ASSESSMENT PARAMETERS - SOIL INHALATION
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Inhalation Rate, (mg/cu m)	20
Exposure Time (hours/day)	8
Exposure Frequency (days/year)	250
Exposure Duration (years)	0.08
Body Weight (kilograms)	70
Averaging Time (years)	
Carcinogens	70
Noncarcinogens	0.08

TABLE R-8 DAILY INTAKE
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Benzo(a)pyrene	2.210E-06	0.08	20	8	250	70	29.2	3.460E-06
Dibenzofuran	1.721E-06	0.08	20	8	250	70	29.2	2.694E-06
Phenanthrene	5.588E-06	0.08	20	8	250	70	29.2	8.748E-06

TABLE R-9 DAILY INTAKE - ADULT
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Benzo(a)pyrene	2.210E-06	0.08	20	8	250	70	25550	3.954E-09
Dibenzofuran	1.721E-06	0.08	20	8	250	70	25550	3.079E-09
Phenanthrene	5.588E-06	0.08	20	8	250	70	25550	9.998E-09

TABLE R-10 SOIL INHALATION MODEL CALCULATIONS
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Construction work		
Dust Loading Factor (g/m^3)	600	g/m^3
Conversion Factor	0.001	mg/g

Computations	Benzo(a)pyrene	Dibenzofuran	Phenanthrene
C(i), mg/kg	0.220994	0.17206695	0.55879078
W(i)/W, g/g	2.21E-06	1.7206695E-06	5.5879078E-06
C(air), mg/m^3	1.33E-06	1.0324017E-06	3.35274468E-06

TABLE R-11 SOIL INHALATION MODEL CALCULATION
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Construction Traffic					
Dust Loading Factor (g/m^3)	400	g/m^3			
Conversion Factor	0.001	mg/g			
Computations			Benzo(a)pyrene	Dibenzofuran	Phenanthrene
C(i), mg/kg			0.220994	0.17206695	0.55879078
W(i)/W, g/g			2.21E-06	1.7206695E-06	5.5879078E-06
C(air), mg/m^3			8.84E-07	6.882678E-07	2.23516312E-06

TABLE R-14 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effects
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	EXCAVATION Chemical-Specific Risk	Total Pathway Risk
Benzo(a)pyrene	1.04E-06		0.3	NA	HEAST 93 (1)	1		
Dibenzofuran	8.13E-07		NO DATA	NA	HEAST 93 (1)	1	3E-06	
Phenanthrene	2.62E-06		0.3	NA	HEAST 93 (1)	1		
							9E-06	
Total								1E-05

1). Subchronic RfD for pyrene was used (HEAST 93)

TABLE R-15 CANCER ESTIMATE - SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effects
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1		Weight of Evidence	Type of Cancer	SF Source	EXCAVATION Chemical-Specific Risk	
Benzo(a)pyrene	1.186E-09	NO	7.3		B2	Fore Stomach	HEAST 93	9E-09	
Dibenzofuran	9.286E-10	NO	NO EVIDENCE	NA		Lung, Thorax, Liver, Skin	HEAST 93	0E+00	
Phenanthrene	2.999E-09	NO	NO EVIDENCE	NA			HEAST 93	0E+00	
								0E+00	
Total									9E-09

1) Oral slope factor for Benzo(a)pyrene was used

TABLE R-12 CANCER ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Carcinogenic Effects
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	CDI Adjusted for Absorption	*SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Excavation Chemical-Specific Risk	Total Pathway Risk
Benzo(a)pyrene	5.339E-09	YES	43	B2			2E-07	
Dibenzofuran	4.180E-09	YES	NO EVIDENCE		NA	(a)	0E+00	
Phenanthrene	1.350E-08	YES	No Evidence	NA	NA	(a)	0E+00	
Total								2E-07

(a) SF for benzo(a) pyrene used (IRIS, 93).
* Adjusted from administered and absorbed dose by assuming an efficiency of 0.17 (ASTDR 1990 for benzp(a)pyrene) and 0.67 for Chrysene (ASTDR, 1990)

TABLE R-13 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Noncarcinogenic Effects
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Excavation Chemical-Specific Risk	Total Pathway Risk
Benzo(a)pyrene	4.672E-06	YES	0.05	NA	(a)	1	9E-05	
Dibenzofuran	3.638E-06	YES	NO DATA	NA	(a)	1	2E-04	
Phenanthrene	1.181E-05	YES	0.05	NA	(a)	1		
Total								3E-04

(a) RfD for benzo(a) pyrene used (HEAST, 93).

TABLE R-16 CANCER RISK ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Carcinogenic Effects
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Excavation CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Excavation Chemical-Specific Risk	Total Pathway Risk
Benzo(a)pyrene	3.954E-09	NO	7.3	B2	Respiratory Tract	IRIS 93	3E-08	
Dibenzofuran	3.079E-09	NO	NO EVIDENCE	NA	NA	NA	0E+00	
Phenanthrene	9.998E-09	NO	NO EVIDENCE	NA	NA	NA		
Total								3E-08

1) Oral slope factor for benzo(a)pyrene was used, IRIS.

TABLE R-17 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Noncarcinogenic Effects
Site 3, Former County Garage, Alpena CRTC, Alpena, MI

Chemical	Excavation CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Excavation Chemical-Specific Risk	Total Pathway Risk
Benzo(a)pyrene	3.460E-06		0.3	NA	HEAST 93	1	1E-05	
Dibenzofuran	2.694E-06		ND	NA	HEAST 93	1		
Phenanthrene	8.748E-06	NO	0.0057	Liver	CA EPA 92	1	2E-03	
Total								2E-03

* RfD for corresponding subchronic oral RfD was used.

Groundwater Solute Transport Model Data - Site 3

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.

2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.

3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.

4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.

5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.

6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft^2/day at TF4-MW3 to 15,290 ft^2/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and

Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^{n} (h_m - h_s)_i^2]^{0.5}$$

n = number of wells
h_m = measured head
h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = 128.78/38 = 3.3891
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

* The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).

* The initial head data input to the transport model are results of measurements taken in September 1993.

* Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.

* Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.

* The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.

* The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 3

No organic compounds or inorganics exceeding the Act 307 Type A or B cleanup criteria were present in the shallow aquifer at this site.

Appendix S: Site 4 Risk Assessment

Table S-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 4
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-TF4	MW1	PC-TF4-MW1-GW4	GROUNDWATER	bis(2-Ethylhexyl)phthalate	3.2000

Table S-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Sediment - Site 4
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE		RESULT
PC-TF4	SD001	PC-TF4-SD001	SEDIMENT	4-Methylphenol	0.0000	0.0000	365.0000
PC-TF4	SD001	PC-TF4-SD001	SEDIMENT	Selenium	0.0000	0.0000	1.1000
PC-TF4	SD001A	PC-TF4-SD001A	SEDIMENT	Methylene chloride	0.0000	0.0000	4.2000
PC-TF4	SD001A	PC-TF4-SD001A	SEDIMENT	Selenium	0.0000	0.0000	0.2150
PC-TF4	SD001A	PC-TF4-SD001A	SEDIMENT	4-Methylphenol	0.0000	0.0000	235.0000
PC-TF4	SD002B	PC-TF4-SD002B	SEDIMENT	Selenium	0.0000	0.0000	0.2150
PC-TF4	SD002B	PC-TF4-SD002B	SEDIMENT	Methylene chloride	0.0000	0.0000	5.6000
PC-TF4	SD002B	PC-TF4-SD002B	SEDIMENT	4-Methylphenol	0.0000	0.0000	235.0000
PC-TF4	SD003	PC-TF4-SD003	SEDIMENT	4-Methylphenol	0.0000	0.0000	220.0000
PC-TF4	SD003	PC-TF4-SD003	SEDIMENT	Selenium	0.0000	0.0000	0.4200
PC-TF4	SD003	PC-TF4-SD003	SEDIMENT	Methylene chloride	0.0000	0.0000	12.0000
PC-TF4	SD004A	PC-TF4-SD004A	SEDIMENT	Methylene chloride	0.0000	0.0000	4.9000
PC-TF4	SD004A	PC-TF4-SD004A	SEDIMENT	4-Methylphenol	0.0000	0.0000	215.0000
PC-TF4	SD004A	PC-TF4-SD004A	SEDIMENT	Selenium	0.0000	0.0000	0.1950
PC-TF4	SD004B	PC-TF4-SD004B	SEDIMENT	Methylene chloride	0.0000	0.0000	2.8000
PC-TF4	SD004B	PC-TF4-SD004B	SEDIMENT	Selenium	0.0000	0.0000	0.2000
PC-TF4	SD004B	PC-TF4-SD004B	SEDIMENT	4-Methylphenol	0.0000	0.0000	217.0000
PC-TF4	SD005A	PC-TF4-SD005A	SEDIMENT	4-Methylphenol	0.0000	0.0000	315.0000
PC-TF4	SD005A	PC-TF4-SD005A	SEDIMENT	Selenium	0.0000	0.0000	0.7200
PC-TF4	SD005B	PC-TF4-SD005B	SEDIMENT	4-Methylphenol	0.0000	0.0000	215.0000
PC-TF4	SD005B	PC-TF4-SD005B	SEDIMENT	Selenium	0.0000	0.0000	0.2000
PC-TF4	SD005B	PC-TF4-SD005B	SEDIMENT	Methylene chloride	0.0000	0.0000	16.0000
PC-TF4	SD006A	PC-TF4-SD006A	SEDIMENT	Selenium	0.0000	0.0000	0.2000
PC-TF4	SD006A	PC-TF4-SD006A	SEDIMENT	4-Methylphenol	0.0000	0.0000	215.0000
PC-TF4	SD006A	PC-TF4-SD006A	SEDIMENT	Methylene chloride	0.0000	0.0000	2.9000
PC-TF4	SD006B	PC-TF4-SD006B	SEDIMENT	Selenium	0.0000	0.0000	0.2200
PC-TF4	SD006B	PC-TF4-SD006B	SEDIMENT	4-Methylphenol	0.0000	0.0000	144.0000
PC-TF4	SD009A	PC-TF4-SD009A	SEDIMENT	Methylene chloride	0.0000	0.0000	1.9000
PC-TF4	SD009A	PC-TF4-SD009A	SEDIMENT	4-Methylphenol	0.0000	0.0000	170.0000
PC-TF4	SD009A	PC-TF4-SD009A	SEDIMENT	Selenium	0.0000	0.0000	0.1550
PC-TF4	SD010A	PC-TF4-SD010A	SEDIMENT	4-Methylphenol	0.0000	0.0000	250.0000
PC-TF4	SD010A	PC-TF4-SD010A	SEDIMENT	Selenium	0.0000	0.0000	0.2300
PC-TF4	SD010A	PC-TF4-SD010A	SEDIMENT	Methylene chloride	0.0000	0.0000	0.7500

Table S-3A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Surface Water - Site 4
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-TF4	SW006	PC-TF4-SW006	SURFACE WATER	Selenium, Dissolved	3.5000
PC-TF4	SW007	PC-TF4-SW007	SURFACE WATER	Selenium, Dissolved	1.5000
PC-TF4	SW008	PC-TF4-SW008	SURFACE WATER	Selenium, Dissolved	1.5000
PC-TF4	SW006	PC-TF4-SW006	SURFACE WATER	Trichloroethylene	1.2000
PC-TF4	SW007	PC-TF4-SW007	SURFACE WATER	Trichloroethylene	0.1500
PC-TF4	SW008	PC-TF4-SW008	SURFACE WATER	Trichloroethylene	0.0950

TABLE S-1 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH SEDIMENTS
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (cm^2/day)	3120	1490
Soil to Skin Adherence Factor (mg/cm^2)	2.77	2.77
Absorption Factor, Unitless		
Metals	0.01	0.01
Organics	0.25	0.25
Exposure Factor (days/year)	48	48
Exposure Duration (year)	25	15
Body Weight (kilograms)	70	27
Conversion Factor	1E-06	1E-06
Averaging Time, years		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE S-2 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Selenium	4.875E-01	1.00E-06	3120	2.77	0.01	48	25	70	9125	7.915E-08
Methylene chloride	8.802E-03	1.00E-06	3120	2.77	0.25	48	25	70	9125	3.573E-08
4-Methylphenol	2.634E-01	1.00E-06	3120	2.77	0.25	48	25	70	9125	1.069E-06

TABLE S-3 DAILY INTAKE - CHILD
DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Selenium	4.875E-01	1.00E-06	1490	2.77	0.01	48	15	27	5475	9.800E-08
Methylene chloride	8.802E-03	1.00E-06	1490	2.77	0.25	48	15	27	5475	4.424E-08
4-Methylphenol	2.634E-01	1.00E-06	1490	2.77	0.25	48	15	27	5475	1.324E-06

TABLE S-4 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Selenium	4.875E-01	1.0E-06	3120	2.77	0.01	48	25	70	25550	2.827E-08
Methylene chloride	8.802E-03	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.276E-08
4-Methylphenol	2.634E-01	1.0E-06	3120	2.77	0.25	48	25	70	25550	3.818E-07

TABLE S-5 DAILY INTAKE - CHILD
DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Selenium	4.875E-01	1.0E-06	1490	2.77	0.01	48	15	27	25550	2.100E-08
Methylene chloride	8.802E-03	1.0E-06	1490	2.77	0.25	48	15	27	25550	9.479E-09
4-Methylphenol	2.634E-01	1.0E-06	1490	2.77	0.25	48	15	27	25550	2.836E-07

TABLE S-6 EXPOSURE ASSESSMENT PARAMETERS - SEDIMENT INGESTION
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	CHILD	ADULT
Ingestion Rate (mg/day)	200	100
Fraction Ingested from Contaminated Sources (unitless)	1	1
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	6	25
Body Weight (kilograms)	15	70
Conversion Factor	1E-06	1E-06
Averaging Time		
Carcinogens	70	70
Noncarcinogens	6	25

TABLE S-7 DAILY INTAKE - ADULT
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Selenium	4.875E-01	1E-06	100	1	48	25	70	9125	9.158E-08
Methylene chloride	8.802E-03	1E-06	100	1	48	25	70	9125	1.654E-09
4-Methylphenol	2.634E-01	1E-06	100	1	48	25	70	9125	4.948E-08

TABLE S-8 DAILY INTAKE CHILD
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Selenium	4.875E-01	1E-06	200	1	48	6	15	2190	8.548E-07
Methylene chloride	8.802E-03	1E-06	200	1	48	6	15	2190	1.543E-08
4-Methylphenol	2.634E-01	1E-06	200	1	48	6	15	2190	4.618E-07

TABLE S-9 DAILY INTAKE - ADULT
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Selenium	4.875E-01	1E-06	100	1	48	25	70	25550	3.271E-08
Methylene chloride	8.802E-03	1E-06	100	1	48	25	70	25550	5.906E-10
4-Methylphenol	2.634E-01	1E-06	100	1	48	25	70	25550	1.767E-08

TABLE S-10 DAILY INTAKE - CHILD
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Selenium	4.875E-01	1E-06	200	1	48	6	15	25550	7.327E-08
Methylene chloride	8.802E-03	1E-06	200	1	48	6	15	25550	1.323E-09
4-Methylphenol	2.634E-01	1E-06	200	1	48	6	15	25550	3.958E-08

TABLE S-11 EXPOSURE ASSESSMENT PARAMETERS - FISH INGESTION
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Fraction of Fish Ingested, unitless	0.5	0.5
Ingestion rate kg/day	0.054	0.043
Exposure Frequency days/yr	26	26
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE S-12 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical * Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.680E-02	0.054	26	0.5	25	70	9125	1.286E-06
Selenium, dissolved	3.500E-03	0.054	26	0.5	25	70	9125	9.616E-08
Carbon Tetrachloride	1.377E-03	0.054	26	0.5	25	70	9125	3.783E-08
Tetrachloroethylene	1.624E-03	0.054	26	0.5	25	70	9125	4.462E-08
Arsenic	2.000E-06	0.054	26	0.5	25	70	9125	5.495E-11
Benzene	3.722E-02	0.054	26	0.5	25	70	9125	1.023E-06
Styrene	1.000E-03	0.054	26	0.5	25	70	9125	2.748E-08
1,2 Dichlorethane	2.000E-05	0.054	26	0.5	25	70	9125	5.495E-10
1,4 Dichlorobenzene	6.300E-03	0.054	26	0.5	25	70	9125	1.731E-07
2 Methylnapthalene	5.100E-03	0.054	26	0.5	25	70	9125	1.401E-07
Lead	4.000E-04	0.054	26	0.5	25	70	9125	1.099E-08

* Adjusted from surface water to fish concentrations by use of bioconcentration factors, Cr=20, Cu=50.

TABLE S-13 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical * Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.680E-02	0.043	26	0.5	15	27	5475	2.655E-06
Selenium, dissolved	3.500E-03	0.043	26	0.5	15	27	5475	1.985E-07
Carbon Tetrachloride	1.377E-03	0.043	26	0.5	15	27	5475	7.811E-08
Tetrachloroethylene	1.624E-03	0.043	26	0.5	15	27	5475	9.212E-08
Arsenic	2.000E-06	0.043	26	0.5	15	27	5475	1.134E-10
Benzene	3.722E-02	0.043	26	0.5	15	27	5475	2.111E-06
Styrene	1.000E-03	0.043	26	0.5	15	27	5475	5.672E-08
1,2 Dichlorethane	2.000E-05	0.043	26	0.5	15	27	5475	1.134E-09
1,4 Dichlorobenzene	6.300E-03	0.043	26	0.5	15	27	5475	3.574E-07
2 Methylnapthalene	5.100E-03	0.043	26	0.5	15	27	5475	2.893E-07
Lead	4.000E-04	0.043	26	0.5	15	27	5475	2.269E-08

* Adjusted from surface water to fish concentrations by use of bioconcentration factors, Cr=20, Cu=50.

TABLE S-14 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.680E-02	0.054	26	0.5	25	70	25550	4.592E-07
Selenium, dissolved	3.500E-03	0.054	26	0.5	25	70	25550	3.434E-08
Carbon Tetrachloride	1.377E-03	0.054	26	0.5	25	70	25550	1.351E-08
Tetrachloroethylene	1.624E-03	0.054	26	0.5	25	70	25550	1.594E-08
Arsenic	2.000E-06	0.054	26	0.5	25	70	25550	1.963E-11
Benzene	3.722E-02	0.054	26	0.5	25	70	25550	3.653E-07
Styrene	1.000E-03	0.054	26	0.5	25	70	25550	9.813E-09
1,2 Dichlorethane	2.000E-05	0.054	26	0.5	25	70	25550	1.963E-10
1,4 Dichlorobenzene	6.300E-03	0.054	26	0.5	25	70	25550	6.182E-08
2 Methylnapthalene	5.100E-03	0.054	26	0.5	25	70	25550	5.004E-08
Lead	4.000E-04	0.054	26	0.5	25	70	25550	3.925E-09

TABLE S-15 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.680E-02	0.043	26	0.5	15	27	25550	5.688E-07
Selenium, dissolved	3.500E-03	0.043	26	0.5	15	27	25550	4.254E-08
Carbon Tetrachloride	1.377E-03	0.043	26	0.5	15	27	25550	1.674E-08
Tetrachloroethylene	1.624E-03	0.043	26	0.5	15	27	25550	1.974E-08
Arsenic	2.000E-06	0.043	26	0.5	15	27	25550	2.431E-11
Benzene	3.722E-02	0.043	26	0.5	15	27	25550	4.525E-07
Styrene	1.000E-03	0.043	26	0.5	15	27	25550	1.215E-08
1,2 Dichlorethane	2.000E-05	0.043	26	0.5	15	27	25550	2.431E-10
1,4 Dichlorobenzene	6.300E-03	0.043	26	0.5	15	27	25550	7.658E-08
2 Methylnapthalene	5.100E-03	0.043	26	0.5	15	27	25550	6.199E-08
Lead	4.000E-04	0.043	26	0.5	15	27	25550	4.862E-09

TABLE S-16 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF SURFACE WATER
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Exposure Time (hrs/day)	2.6	2.6
Surface Water Contact Rate (ml/hr)	50	50
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE S-17 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/hr)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.816E-04	0.050	48	2.6	25	70	9125	1.176E-07
Selenium, dissolved	2.100E-03	0.050	48	2.6	25	70	9125	5.129E-07
Carbon Tetrachloride	8.100E-05	0.050	48	2.6	25	70	9125	1.978E-08
Tetrachloroethylene	2.900E-05	0.050	48	2.6	25	70	9125	7.083E-09
Arsenic	2.000E-06	0.050	48	2.6	25	70	9125	4.885E-10
Benzene	1.551E-03	0.050	48	2.6	25	70	9125	3.788E-07
Styrene	1.000E-05	0.050	48	2.6	25	70	9125	2.442E-09
1,2 Dichlorethane	1.000E-05	0.050	48	2.6	25	70	9125	2.442E-09
1,4 Dichlorobenzene	1.050E-04	0.050	48	2.6	25	70	9125	2.564E-08
2 Methylnapthalene	1.000E-05	0.050	48	2.6	25	70	9125	2.442E-09
Lead	4.000E-06	0.050	48	2.6	25	70	9125	9.769E-10

TABLE S-18 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/hr)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.816E-04	0.050	48	2.6	15	27	5475	3.049E-07
Selenium, dissolved	2.100E-03	0.050	48	2.6	15	27	5475	1.330E-06
Carbon Tetrachloride	8.100E-05	0.050	48	2.6	15	27	5475	5.129E-08
Tetrachloroethylene	2.900E-05	0.050	48	2.6	15	27	5475	1.836E-08
Arsenic	2.000E-06	0.050	48	2.6	15	27	5475	1.266E-09
Benzene	1.551E-03	0.050	48	2.6	15	27	5475	9.821E-07
Styrene	1.000E-05	0.050	48	2.6	15	27	5475	6.332E-09
1,2 Dichlorethane	1.000E-05	0.050	48	2.6	15	27	5475	6.332E-09
1,4 Dichlorobenzene	1.050E-04	0.050	48	2.6	15	27	5475	6.648E-08
2 Methylnapthalene	1.000E-05	0.050	48	2.6	15	27	5475	6.332E-09
Lead	4.000E-06	0.050	48	2.6	15	27	5475	2.533E-09

TABLE S-19 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/hr)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	4.816E-04	0.050	48	2.6	25	70	25550	4.201E-08
Selenium, dissolved	2.100E-03	0.050	48	2.6	25	70	25550	1.832E-07
Carbon Tetrachloride	8.100E-05	0.050	48	2.6	25	70	25550	7.065E-09
Tetrachloroethylene	2.900E-05	0.050	48	2.6	25	70	25550	2.529E-09
Arsenic	2.000E-06	0.050	48	2.6	25	70	25550	1.744E-10
Benzene	1.551E-03	0.050	48	2.6	25	70	25550	1.353E-07
Styrene	1.000E-05	0.050	48	2.6	25	70	25550	8.722E-10
1,2 Dichlorethane	1.000E-05	0.050	48	2.6	25	70	25550	8.722E-10
1,4 Dichlorobenzene	1.050E-04	0.050	48	2.6	25	70	25550	9.159E-09
2 Methylnapthalene	1.000E-05	0.050	48	2.6	25	70	25550	8.722E-10
Lead	4.000E-06	0.050	48	2.6	25	70	25550	3.489E-10

TABLE S-20 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/hr)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Trichloroethylene	1.200E-03	0.050	48	2.6	15	27	25550	1.628E-07
Selenium, dissolved	3.500E-03	0.050	48	2.6	15	27	25550	4.749E-07
Carbon Tetrachloride	8.100E-05	0.050	48	2.6	15	27	25550	1.099E-08
Tetrachloroethylene	2.900E-05	0.050	48	2.6	15	27	25550	3.935E-09
Arsenic	2.000E-06	0.050	48	2.6	15	27	25550	2.714E-10
Benzene	1.551E-03	0.050	48	2.6	15	27	25550	2.104E-07
Styrene	1.000E-05	0.050	48	2.6	15	27	25550	1.357E-09
1,2 Dichlorethane	1.000E-05	0.050	48	2.6	15	27	25550	1.357E-09
1,4 Dichlorobenzene	1.050E-04	0.050	48	2.6	15	27	25550	1.425E-08
2 Methylnapthalene	1.000E-05	0.050	48	2.6	15	27	25550	1.357E-09
Lead	4.000E-06	0.050	48	2.6	15	27	25550	5.427E-10

TABLE S-21 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH THUNDERBAY RIVER SURFACE WATER
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	2.6	2.6
Dermal Permeability Constant	0.00084	0.00084
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	

TABLE S-22 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Trichloroethylene	(a)	1.200E-03	0.2	19400	48	2.6	25	70	9125	0.001	2.274E-05
Selenium, dissolved	(c)	3 500E-03	0.001	19400	48	2.6	25	70	9125	0.001	3.317E-07
Carbon Tetrachloride	(b)	8.100E-05	0.022	19400	48	2.6	25	70	9125	0.001	1.689E-07
Tetrachloroethylene	(a)	2.900E-05	0.4	19400	48	2.6	25	70	9125	0.001	1.099E-06
Arsenic	(c)	2.000E-06	0.001	19400	48	2.6	25	70	9125	0.001	1.895E-10
Benzene	(a)	1.551E-03	0.1	19400	48	2.6	25	70	9125	0.001	1.470E-05
Styrene		1.000E-05	0.00084	19400	48	2.6	25	70	9125	0.001	7.960E-10
1,2 Dichlorethane	(b)	1.000E-05	0.0053	19400	48	2.6	25	70	9125	0.001	5.022E-09
1,4 Dichlorobenzene	(b)	1.050E-04	0.062	19400	48	2.6	25	70	9125	0.001	6.169E-07
2 Methylnapthalene	(c)	1.000E-05	0.001	19400	48	2.6	25	70	9125	0.001	9.476E-10
Lead	(a)	4.000E-06	4E-06	19400	48	2.6	25	70	9125	0.001	1.516E-12

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).
(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

TABLE S-23 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Trichloroethylene	(a)	1.200E-03	0.2	13300	48	2.6	15	27	5475	0.001	4.042E-05
Selenium, dissolved	(b)	3.500E-03	0.001	13300	48	2.6	15	27	5475	0.001	5.895E-07
Carbon Tetrachloride	(b)	8.100E-05	0.022	13300	48	2.6	15	27	5475	0.001	3.001E-07
Tetrachloroethylene	(a)	2.900E-05	0.4	13300	48	2.6	15	27	5475	0.001	1.954E-06
Arsenic	(c)	2.000E-06	0.001	13300	48	2.6	15	27	5475	0.001	3.369E-10
Benzene	(a)	1.551E-03	0.1	13300	48	2.6	15	27	5475	0.001	2.612E-05
Styrene		1.000E-05	0.00084	13300	48	2.6	15	27	5475	0.001	1.415E-09
1,2 Dichlorethane	(b)	1.000E-05	0.0053	13300	48	2.6	15	27	5475	0.001	8.927E-09
1,4 Dichlorobenzene	(b)	1.050E-04	0.062	13300	48	2.6	15	27	5475	0.001	1.096E-06
2 Methylnapthalene	(c)	1.000E-05	0.001	13300	48	2.6	15	27	5475	0.001	1.684E-09
Lead	(a)	4.000E-06	4E-06	13300	48	2.6	15	27	5475	0.001	2.695E-12

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).
(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

TABLE S-24 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Trichloroethylene	(a)	1.200E-03	0.2	19400	48	2.6	25	70	25550	0.001	8.122E-06
Selenium, dissolved	(b)	3.500E-03	0.001	19400	48	2.6	25	70	25550	0.001	1.185E-07
Carbon Tetrachloride	(b)	8.100E-05	0.022	19400	48	2.6	25	70	25550	0.001	6.031E-08
Tetrachloroethylene	(a)	2.900E-05	0.4	19400	48	2.6	25	70	25550	0.001	3.926E-07
Arsenic	(c)	2.000E-06	0.001	19400	48	2.6	25	70	25550	0.001	6.769E-11
Benzene	(a)	1.551E-03	0.1	19400	48	2.6	25	70	25550	0.001	5.249E-06
Styrene		1.000E-05	0.00084	19400	48	2.6	25	70	25550	0.001	2.843E-10
1,2 Dichlorethane	(b)	1.000E-05	0.0053	19400	48	2.6	25	70	25550	0.001	1.794E-09
1,4 Dichlorobenzene	(b)	1.050E-04	0.062	19400	48	2.6	25	70	25550	0.001	2.203E-07
2 Methylnapthalene	(c)	1.000E-05	0.001	19400	48	2.6	25	70	25550	0.001	3.384E-10
Lead	(a)	4.000E-06	4E-06	19400	48	2.6	25	70	25550	0.001	5.415E-13

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).
(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical-specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

TABLE S-25 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Trichloroethylene	(a)	1.200E-03	0.2	13300	48	2.6	15	27	25550	0.001	8.662E-06
Selenium, dissolved	(b)	3.500E-03	0.001	13300	48	2.6	15	27	25550	0.001	1.263E-07
Carbon Tetrachloride	(b)	8.100E-05	0.022	13300	48	2.6	15	27	25550	0.001	6.431E-08
Tetrachloroethylene	(a)	2.900E-05	0.4	13300	48	2.6	15	27	25550	0.001	4.187E-07
Arsenic	(c)	2.000E-06	0.001	13300	48	2.6	15	27	25550	0.001	7.218E-11
Benzene	(a)	1.551E-03	0.1	13300	48	2.6	15	27	25550	0.001	5.598E-06
Styrene		1.000E-05	0.00084	13300	48	2.6	15	27	25550	0.001	3.032E-10
1,2 Dichlorethane	(b)	1.000E-05	0.0053	13300	48	2.6	15	27	25550	0.001	1.913E-09
1,4 Dichlorobenzene	(b)	1.050E-04	0.062	13300	48	2.6	15	27	25550	0.001	2.350E-07
2 Methylnapthalene	(c)	1.000E-05	0.001	13300	48	2.6	15	27	25550	0.001	3.609E-10
Lead	(a)	4.000E-06	4E-06	13300	48	2.6	15	27	25550	0.001	5.775E-13

TABLE 8-28 CANCER ESTIMATE - DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO - ADULTS/CHILDREN

Carcinogenic Effects
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF * (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Selenium	2.827E-08	2.100E-08	YES	NO EVIDENCE				0E+00		0E+00	
Methylene chloride	1.276E-08	9.479E-09	YES	7.65E-03	B2	Liver	IRIS 93	1E-10		7E-11	
4-Methylphenol	3.818E-07	2.836E-07	YES	NO DATA	C	NA	NA	0E+00		0E+00	
Total									1E-10		7E-11

* Adjusted for administered to absorbed using oral absorption efficiency factors, As=0.95 (ASTDR 1991), Cr=0.11 (ASTDR 1989), MeCl 0.98 (ASTDR 1991)

TABLE S-27 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO - ADULTS/CHILDREN

Noncarcinogenic Effects
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Selenium	7.915E-08	9.800E-08	YES	0.005	Clinical Selenosis	IRIS 93	1	2E-05		2E-05	
Methylene chloride	3.573E-08	4.424E-08	YES	0.0588	Liver	IRIS 93	1	6E-07		8E-07	
4-Methylphenol	1.069E-06	1.324E-06	YES	0.003725	Decreased body weight	HEAST 83	1	3E-04		4E-04	
Total									3E-04		4E-04

* Adjusted for administered to absorbed using oral absorption efficiency factors, As=0.95 (ASTDR 1991), Cr=0.11 (ASTDR 1989), MeCl 0.98 (ASTDR 1991), Se 0.935 (ASTDR 1989), 4-Methylphenol 0.745 (ASTDR 1992)

TABLE 8-28 CANCER ESTIMATE - SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - ADULTS/CHILDREN

Cardinogenic Effects
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Child Chemical-Specific Risk	Total Pathway Risk
Selenium	3.271E-08	7.327E-08	NO	NO EVIDENCE				0E+00	0E+00	
Methylene chloride	5.906E-10	1.323E-09	NO	0.0075	B2	Liver	IRIS 93	4E-12	1E-11	
4-Methylphenol	1.767E-08	3.958E-08	NO	NO DATA	C	Skin	NA	0E+00	0E+00	
Total								4E-12		1E-11

1) Converted from a unit risk of 5 X 10E-05 ug/L given in IRIS.

TABLE S-29 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - ADULTS/CHILDREN

Noncarcinogenic Effects
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Child Chemical-Specific Risk	Total Pathway Risk
Selenium	9.158E-08	8.548E-07	NO	0.005	Clinical selenosis	IRIS 93	1	2E-05	2E-04	
Methylene chloride	1.654E-09	1.543E-08	NO	0.06	Liver	IRIS 93	1	3E-08	3E-07	
4-Methylphenol	4.948E-08	4.618E-07	NO	0.005	Decreased body weight	HEAST 83		1E-05	9E-05	
Total								3E-05		3E-04

TABLE S-30 CANCER ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Trichloroethylene	4.592E-07	5.688E-07	NO	0.01	B2	Lung	CA EPA 92 (1)	5E-09		6E-09	
Selenium, dissolved	3.434E-08	4.254E-08	NO	NO EVIDENCE		NA		0E+00		0E+00	
Carbon Tetrachloride	1.351E-08	1.674E-08	NO	0.13	B2	Heptocellular carcinomas	IRIS 93	2E-09		2E-09	
Tetrachloroethylene	1.594E-08	1.974E-08	NO	0.051	B2	Liver	CA EPA 92	8E-10		1E-09	
Arsenic	1.963E-11	2.431E-11	NO	1.8	A	Skin, Lung	IRIS 93	4E-11		4E-11	
Benzene	3.653E-07	4.525E-07	NO	0.029	A	Leukemia	IRIS 93	1E-08		1E-08	
Styrene	9.813E-09	1.215E-08	NO	NO DATA	NA	NA	NA	0E+00		0E+00	
1,2 Dichlorethane	1.963E-10	2.431E-10	NO	0.091	B2	Hemangiosarcomas	IRIS 93	2E-11		2E-11	
1,4 Dichlorobenzene	6.182E-08	7.658E-08	NO	0.024	C	Liver tumors	HEAST 93	1E-09		2E-09	
2 Methylnapthalene	5.004E-08	6.199E-08	NO	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Lead	3.925E-09	4.862E-09	NO	NO DATA	B2	Kidney	NA	0E+00		0E+00	
Total									2E-08		2E-08

TABLE S-31 CHRONIC HAZARDOUS INDEX ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Trichloroethylene	1.286E-06	2.655E-06	NO	0.00735	Red blood cells	CA EPA 92	1	2E-04		4E-04	
Selenium, dissolved	9.616E-08	1.985E-07	NO	0.005	Clinical Selenosis	IRIS, 1993	1	2E-05		4E-05	
Carbon Tetrachloride	3.783E-08	7.811E-08	NO	0.0007	Liver Lesions	IRIS, 1993	1	5E-05		1E-04	
Tetrachloroethylene	4.462E-08	9.212E-08	NO	0.01	Hepatotoxicity	IRIS, 1993	1	4E-06		9E-06	
Arsenic	5.495E-11	1.134E-10	NO	0.0003	Keratosis	IRIS, 1993	1	2E-07		4E-07	
Benzene	1.023E-06	2.111E-06	NO	No Data	NA	NA	NA				
Styrene	2.748E-08	5.672E-08	NO	0.2	Red blood cell and liver	IRIS, 1993	1	1E-07		3E-07	
1,2 Dichlorethane	5.495E-10	1.134E-09	NO	No Data	NA	NA	NA				
1,4 Dichlorobenzene	1.731E-07	3.574E-07	NO	No Data	NA	NA	NA				
2 Methylnapthalene	1.401E-07	2.893E-07	NO	0.03	NA	NA	NA	5E-06		1E-05	
Lead	1.099E-08	2.269E-08	NO	No Data	NA	NA	NA				
Total									3E-04		5E-04

1) RfD calculated from conversion of 1.3 mg/L drinking water standard.

TABLE S-32 CANCER ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical		Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Trichloroethylene		4.201E-08	4.592E-07	NO	0.01	B2	Lung	CA EPA 92 (1)	4E-10		5E-09	
Selenium, dissolved		1.832E-07	3.434E-08	NO	NO EVIDENCE		NA		0E+00		0E+00	
Carbon Tetrachloride		7.065E-09	1.099E-08	NO	0.13	B2	Heptocellular carcinomas	IRIS 93	9E-10		1E-09	
Tetrachloroethylene		2.529E-09	3.935E-09	NO	0.051	B2	Liver	CA EPA 92	1E-10		2E-10	
Arsenic	(a)	1.744E-10	2.714E-10	NO	1.8	A	Skin, Lung	IRIS 93	3E-10		5E-10	
Benzene		1.353E-07	2.104E-07	NO	0.029	A	Leukemia	IRIS 93	4E-09		6E-09	
Styrene	(b)	8.722E-10	1.357E-09	NO	NO DATA	NA	NA	NA	0E+00		0E+00	
1,2 Dichlorethane		8.722E-10	1.357E-09	NO	0.091	B2	Hemangiosarcomas	IRIS 93	8E-11		1E-10	
1,4 Dichlorobenzene		9.159E-09	1.425E-08	NO	0.024	C	Liver tumors	Heast 93	2E-10		3E-10	
2 Methylnapthalene		8.722E-10	1.357E-09	NO	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Lead		3.489E-10	5.427E-10	NO	NO DATA	B2	Kidney	NA	0E+00		0E+00	
Total										6E-09		1E-08

(a)Converted from a unit risk of 5e-5 ug/l given in IRIS
(b) no SF exists for styrene as of 1/5/94. Classified as probable carcinogen by IRAC
1) Data from Cr +6 was used.

TABLE S-33 CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Trichloroethylene	1.176E-07	3.049E-07	NO	0.00735	Red blood cells	CA EPA 92	1	2E-05		4E-05	
Selenium, dissolved	5.129E-07	1.330E-06	NO	0.005	Clinical Selenosis	IRIS, 1993	1	1E-04		3E-04	
Carbon Tetrachloride	1.978E-08	5.129E-08	NO	0.0007	Liver Lesions	IRIS, 1993	1	3E-05		7E-05	
Tetrachloroethylene	7.083E-09	1.836E-08	NO	0.01	Hepatotoxicity	IRIS, 1993	1	7E-07		2E-06	
Arsenic	4.885E-10	1.266E-09	NO	0.0003	Keratosis	IRIS, 1993	1	2E-06		4E-06	
Benzene	3.788E-07	9.821E-07	NO	NA	NA	NA	NA				
Styrene	2.442E-09	6.332E-09	NO	0.2	Red blood cell and liver	IRIS, 1993	1	1E-08		3E-08	
1,2 Dichlorethane	2.442E-09	6.332E-09	NO	No Data	NA	NA	NA				
1,4 Dichlorobenzene	2.564E-08	6.648E-08	NO	No Data	NA	NA	NA				
2 Methylnapthalene	2.442E-09	6.332E-09	NO	0.03	NA	NA	NA	8E-08		2E-07	
Lead	9.769E-10	2.533E-09	NO	No Data	NA	NA	NA				
Total									1E-04		4E-04

TABLE S-34 CANCER ESTIMATE - SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF * (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Trichloroethylene	8.122E-06	8.662E-06	YES	1.76E-02	B2	Lung	CA EPA 92 (1)	1E-07		2E-07	
Selenium, dissolved	1.185E-07	1.263E-07	YES	NO EVIDENCE		NA		0E+00		0E+00	
								0E+00		0E+00	
Carbon Tetrachloride	6.031E-08	6.431E-08	YES	1.44E-01	B2	Heptocellular carcinomas	IRIS 93	9E-09		9E-09	
Tetrachloroethylene	3.926E-07	4.187E-07	YES	0.051	B2	Liver	CA EPA 92	2E-08		2E-08	
Arsenic	6.769E-11	7.218E-11	YES	1.89E+00	A	Skin, Lung	IRIS 93	1E-10		1E-10	
Benzene	5.249E-06	5.598E-06	YES	0.029	A	Leukemia	IRIS 93	2E-07		2E-07	
Styrene	2.843E-10	3.032E-10	YES	NO DATA	NA	NA	NA	0E+00		0E+00	
1,2 Dichlorethane	1.794E-09	1.913E-09	YES	0.091	B2	Hemangiosarcomas	IRIS 93	2E-10		2E-10	
1,4 Dichlorobenzene	2.203E-07	2.350E-07	YES	0.024	C	Liver tumors	heast 93	5E-09		6E-09	
2 Methylnapthalene	3.384E-10	3.609E-10	YES	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Lead	5.415E-13	5.775E-13	YES	NO DATA	B2	Kidney	NA	0E+00		0E+00	
Total									3E-07		4E-07

* Adjusted from administered to absorbed dose by assuming the following oral absorption efficiences: Se 0.935 (ASTDR, 1989), As 0.95 (ASTDR(1991), CCl4 0.9 (ASTDR,1992), PCE 1.0 (ASTDR 1990), Benzene 1.0 (ASTDR 1989), Styrene 1.0 (default), TCE 0.85 (default) 1,2 DCE 1.0 (default), 1,4,DCB 1.0 (ASTDR 1991).

TABLE S-35 CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 4, Third Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Trichloroethylene	2.274E-05	4.042E-05	YES	0.85	Red blood cells	CA EPA 92	1	3E-05		5E-05	
Selenium, dissolved	3.317E-07	5.895E-07	YES	0.004675	Clinical Selenosis	IRIS, 1993	1	7E-05		1E-04	
Carbon Tetrachloride	1.689E-07	3.001E-07	YES	0.00063	Liver Lesions	IRIS, 1993	1	3E-04		5E-04	
Tetrachloroethylene	1.099E-06	1.954E-06	YES	0.01	Hepatotoxicity	IRIS, 1993	1	1E-04		2E-04	
Arsenic	1.895E-10	3.369E-10	YES	0.000285	Keratosis	IRIS, 1993	1	7E-07		1E-06	
Benzene	1.470E-05	2.612E-05	YES	No Data	NA	NA	NA				
Styrene	7.960E-10	1.415E-09	YES	0.2	Red blood cell and liver	IRIS, 1993	1	4E-09		7E-09	
1,2 Dichlorethane	5.022E-09	8.927E-09	YES	No Data	NA	NA	NA				
1,4 Dichlorobenzene	6.169E-07	1.096E-06	YES	No Data	NA	NA	NA				
2 Methylnapthalene	9.476E-10	1.684E-09	YES	0 03	NA	NA	NA	3E-08		6E-08	
Lead	1.516E-12	2.695E-12	YES	No Data	NA	NA	NA				
									5E-04		8E-04

* Adjusted from administered to absorbed dose by assuming the following oral absorption efficiences: Se 0.935 (ASTDR, 1989), As 0.95 (ASTDR(1991), CCl4 0.9 (ASTDR,1992), PCE 1.0 (ASTDR 1990), Benzene 1.0 (ASTDR 1989), Styrene 1.0 (default), TCE 0.85 (default) 1,2 DCE 1.0 (default), 1,4,DCB 1.0 (ASTDR 1991).
1) RfD calculated from conversion of 1.3 mg/L drinking water standard.

Groundwater Solute Transport Model Data - Site 4

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.

2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.

3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.

4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.

5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.

6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft^2/day at TF4-MW3 to 15,290 ft^2/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and

Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^{n} (h_m - h_s)_i^2]^{0.5}$$

n = number of wells
h_m = measured head
h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = 128.78/38 = 3.3891
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

* The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).

* The initial head data input to the transport model are results of measurements taken in September 1993.

* Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.

* Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.

* The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.

* The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 4

No organic compounds were present in the groundwater at Site 4 above Act 307 Type B cleanup criteria. However, model simulations predict that contaminants from sites 2, 5, 6, 8, and 9 would reach the sinkhole after a period of several years with maximum concentrations entering the sinkhole between 5 and 20 years depending on which site the contaminants originate from. PCE, arsenic, and carbon tetrachloride originating from wells MP2MW7, MP2MW1 and PW3 at Site 2 arrive at the sinkhole in concentrations ranging from 0.002 (arsenic) to 0.28 ug/l for PCE. The chemicals 1,2 -DCA, 1,4 -DCB, benzene and styrene originating from well SF5MW1 at Site 5 arrive at the sinkhole at concentrations ranging from 0.01 (styrene) and 1.55 ug/l for benzene. Well LF6MW3 at Site 6 contained carbon tetrachloride which arrived at the sinkhole at an estimated concentration of 0.08 ug/l. Well HN8MW3 at Site 8 contained PCE which arrived at the sinkhole with an estimated concentration of 0.001 ug/l. Well RT9MW6 at Site 9 contained PCE, benzene, 1,4 -DCB, lead, and 2-methylnapthalene which arrived at the sinkhole at concentrations ranging from 0.001 (PCE) to 0.01 ug/l for 2-methylnapthlene.

Appendix T: Site 5 Risk Assessment

Table T-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 5
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-SF5	MW1	PC-SF5-MW1-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW2	PC-SF5-MW2-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW3	PC-SF5-MW3-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW4	PC-SF5-MW4-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW5	PC-SF5-MW5-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW6	PC-SF5-MW6-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW7	PC-SF5-MW7-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW8	PC-SF5-MW8-GW4	GROUNDWATER	1,2-Dichloroethane	0.4400
PC-SF5	MW9	PC-SF5-MW9-GW4	GROUNDWATER	1,2-Dichloroethane	0.1250
PC-SF5	MW1	PC-SF5-MW1-GW4	GROUNDWATER	1,4-Dichlorobenzene	3.5000
PC-SF5	MW2	PC-SF5-MW2-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW3	PC-SF5-MW3-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW4	PC-SF5-MW4-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW5	PC-SF5-MW5-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW6	PC-SF5-MW6-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW7	PC-SF5-MW7-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW9	PC-SF5-MW9-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-SF5	MW1	PC-SF5-MW1-GW4	GROUNDWATER	Benzene	52.0000
PC-SF5	MW2	PC-SF5-MW2-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW3	PC-SF5-MW3-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW4	PC-SF5-MW4-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW5	PC-SF5-MW5-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW6	PC-SF5-MW6-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW7	PC-SF5-MW7-GW4	GROUNDWATER	Benzene	0.1750
PC-SF5	MW8	PC-SF5-MW8-GW4	GROUNDWATER	Benzene	41.0000
PC-SF5	MW9	PC-SF5-MW9-GW4	GROUNDWATER	Benzene	0.2600
PC-SF5	MW1	PC-SF5-MW1-GW4	GROUNDWATER	Styrene	1.5000
PC-SF5	MW2	PC-SF5-MW2-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW3	PC-SF5-MW3-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW4	PC-SF5-MW4-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW5	PC-SF5-MW5-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW6	PC-SF5-MW6-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW7	PC-SF5-MW7-GW4	GROUNDWATER	Styrene	0.1250
PC-SF5	MW8	PC-SF5-MW8-GW4	GROUNDWATER	Styrene	0.6700
PC-SF5	MW9	PC-SF5-MW9-GW4	GROUNDWATER	Styrene	0.1250

TABLE T-1 EXPOSURE ASSESSMENT PARAMETERS - FISH INGESTION
Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Fraction of Fish Ingested, unitless	0.5	0.5
Ingestion rate kg/day	0.054	0.043
Exposure Frequency days/yr	26	26
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE T-2 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Styrene	1.000E-03	0.054	26	0.5	25	70	9125	2.748E-08
Benzene	3.600E-02	0.054	26	0.5	25	70	9125	9.891E-07
1,4-Dichlorobenzene	6.000E-03	0.054	26	0.5	25	70	9125	1.649E-07
1,2-Dichloroethane	2.000E-02	0.054	26	0.5	25	70	9125	5.495E-07

TABLE T-3 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Styrene	1.000E-03	0.043	26	0.5	15	27	5475	5.672E-08
Benzene	3.600E-02	0.043	26	0.5	15	27	5475	2.042E-06
1,4-Dichlorobenzene	6.000E-03	0.043	26	0.5	15	27	5475	3.403E-07
1,2-Dichloroethane	2.000E-02	0.043	26	0.5	15	27	5475	1.134E-06

TABLE T-4 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Styrene	1.000E-03	0.054	26	0.5	25	70	25550	9.813E-09
Benzene	3.600E-02	0.054	26	0.5	25	70	25550	3.533E-07
1,4-Dichlorobenzene	6.000E-03	0.054	26	0.5	25	70	25550	5.888E-08
1,2-Dichloroethane	2.000E-02	0.054	26	0.5	25	70	25550	1.963E-07

TABLE T-5 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Styrene	1.000E-03	0.043	26	0.5	15	27	25550	1.215E-08
Benzene	3.600E-02	0.043	26	0.5	15	27	25550	4.376E-07
1,4-Dichlorobenzene	6.000E-03	0.043	26	0.5	15	27	25550	7.293E-08
1,2-Dichloroethane	2.000E-02	0.043	26	0.5	15	27	25550	2.431E-07

TABLE T-8 CANCER ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Styrene	9.813E-09	1.215E-08	NO	NO EVIDENCE				0E+00		0E+00	
Benzene	3.533E-07	4.376E-07	NO	0.029	A	Leukemia	IRIS, 1993	1E-08		1E-08	
1,4-Dichlorobenzene	5.888E-08	7.293E-08	NO	0.029	C	Liver Tumors	HEAST 93	2E-09		2E-09	
1,2-Dichloroethane	1.963E-07	2.431E-07	NO	0.13	B2	Hemaglosarcomas	IRIS, 1993	3E-08		3E-08	
									4E-08		5E-08

TABLE T-7 CHRONIC HAZARDOUS INDEX ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 5, Second Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Styrene	2.748E-08	5.672E-08	NO	0.2	Red blood cell, Liver	IRIS, 1993	1	1E-07		3E-07	
Benzene	9.891E-07	2.042E-06	NO	NO DATA	NA						
1,4-Dichlorobenzene	1.649E-07	3.403E-07	NO	NO DATA	NA						
1,2-Dichloroethane	5.495E-07	1.134E-06	NO	NO DATA	NA						
									1E-07		3E-07

Groundwater Solute Transport Model Data - Site 5

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.
The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.

2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.

3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.

4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.

5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.

6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft^2/day at TF4-MW3 to 15,290 ft^2/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^{n} (h_m - h_s)_i^2]^{0.5}$$

n = number of wells
h_m = measured head
h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW12	16,25	674.55	675.94	-1.39
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = 128.78/38 = 3.3891
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

* The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).

* The initial head data input to the transport model are results of measurements taken in September 1993.

* Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.

* Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.

* The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.

* The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 5

Several chemicals were detected in well SF5MW1 above MDNR Type A or Type B cleanup criteria. These compounds are 1,2- Dichloroethane, 1,4- Dichlorobenzene, Benzene, and Styrene at concentrations of 0.44, 3.5, 52, and 1.5 ug/l, respectively. Chemical data was input to the model and concentrations of the contaminants were monitored along the eastern shore of Lake Winyah and at the sinkhole with respect to time.

Appendix U: Site 6/7 Risk Assessment

Table U-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 6/7
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-LF6	MW1	PC-LF6-MW1-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW10	PC-LF6-MW10-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW2	PC-LF6-MW2-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW3	PC-LF6-MW3-GW4	GROUNDWATER	Carbon Tetrachloride	1.1000
PC-LF6	MW4	PC-LF6-MW4-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW5	PC-LF6-MW5-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW6	PC-LF6-MW6-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW8	PC-LF6-MW8-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750
PC-LF6	MW9	PC-LF6-MW9-GW4	GROUNDWATER	Carbon Tetrachloride	0.1750

Table U-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Sediment - Site 6/7
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE		RESULT
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Anthracene	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Anthracene	0.0000	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Anthracene	0.0000	0.0000	348.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Benzo(a)anthracene	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Benzo(a)anthracene	0.0000	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Benzo(a)anthracene	0.0000	0.0000	343.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Benzo(a)pyrene	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Benzo(a)pyrene	0.0000	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Benzo(a)pyrene	0.0000	0.0000	278.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Benzo(b)fluoranthene	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Benzo(b)fluoranthene	0.0000	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Benzo(b)fluoranthene	0.0000	0.0000	462.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Benzo(ghi)perylene	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Benzo(ghi)perylene	0.0000	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Benzo(ghi)perylene	0.0000	0.0000	148.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Benzo(k)fluoranthene	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Benzo(k)fluoranthene	0.0000	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Benzo(k)fluoranthene	0.0000	0.0000	462.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Butyl benzyl phthalate	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Butyl benzyl phthalate	0.0000	0.0000	510.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Butyl benzyl phthalate	0.0000	0.0000	60.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Carbazole	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Carbazole	0.0000	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Carbazole	0.0000	0.0000	162.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Chromium	0.0000	0.0000	4.9000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Chromium	0.0000	0.0000	15.9000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Chromium	0.0000	0.0000	6.3000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Chrysene	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Chrysene	0.0000	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Chrysene	0.0000	0.0000	332.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Copper	0.0000	0.0000	6.2000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Copper	0.0000	0.0000	16.4000

Table U-2A (continued)
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Sediment - Site 6/7
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE		RESULT
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Copper	0.0000	0.0000	12.8000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Di-n-butyl phthalate	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Di-n-butyl phthalate	0.0000	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Di-n-butyl phthalate	0.0000	0.0000	150.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Fluoranthene	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Fluoranthene	0.0000	0.0000	540.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Fluoranthene	0.0000	0.0000	442.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Indeno(1,2,3-c,d)pyrene	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Indeno(1,2,3-c,d)pyrene	0.0000	0.0000	1150.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Indeno(1,2,3-c,d)pyrene	0.0000	0.0000	178.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Lead	0.0000	0.0000	5.3000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Lead	0.0000	0.0000	177.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Lead	0.0000	0.0000	40.8000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Nickel	0.0000	0.0000	5.5500
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Nickel	0.0000	0.0000	12.7500
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Nickel	0.0000	0.0000	5.2800
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Phenanthrene	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Phenanthrene	0.0000	0.0000	310.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Phenanthrene	0.0000	0.0000	348.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Pyrene	0.0000	0.0000	550.0000
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Pyrene	0.0000	0.0000	290.0000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Pyrene	0.0000	0.0000	328.0000
PC-LF6	SD1	PC-LF6-SD1	SEDIMENT	Selenium	0.0000	0.0000	0.4750
PC-LF6	SD2	PC-LF6-SD2	SEDIMENT	Selenium	0.0000	0.0000	2.3000
PC-LF6	SD3	PC-LF6-SD3	SEDIMENT	Selenium	0.0000	0.0000	0.2150

TABLE U-1 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH SEDIMENT
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (cm^2/day)	3120	1490
Soil to Skin Adherence Factor (mg/cm^2)	2.77	2.77
Absorption Factor, Unitless		
Metals	0.01	0.01
Organics	0.25	0.25
Exposure Factor (days/year)	48	48
Exposure Duration (year)	25	15
Body Weight (kilograms)	70	27
Conversion Factor	1E-06	1E-06
Averaging Time (years)		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE U-2 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SEDIMENT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Anthracene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Benzo(a)anthracene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Benzo(a)pyrene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Benzo(b)fluoranthene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Benzo(ghi)perylene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Benzo(k)fluoranthene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Butyl benzyl phthalate	5.500E-01	1.00E-06	3120	2.77	0.25	48	25	70	9125	2.232E-06
Carbazole	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Chrysene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Di-n-butyl phthalate	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Fluoranthene	5.500E-01	1.00E-06	3120	2.77	0.25	48	25	70	9125	2.232E-06
Indeno(1,2,3-c,d)pyrene	1.150E+00	1.00E-06	3120	2.77	0.25	48	25	70	9125	4.668E-06
Lead	1.770E+02	1.00E-06	3120	2.77	0.01	48	25	70	9125	2.874E-05
Phenanthrene	5.500E-01	1.00E-06	3120	2.77	0.25	48	25	70	9125	2.232E-06
Pyrene	5.500E-01	1.00E-06	3120	2.77	0.25	48	25	70	9125	2.232E-06
Selenium	2.300E+00	1.00E-06	3120	2.77	0.01	48	25	70	9125	3.734E-07

TABLE U-3 DAILY INTAKE - CHILD
DERMAL CONTACT WITH SEDIMENT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Anthracene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Benzo(a)anthracene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Benzo(a)pyrene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Benzo(b)fluoranthene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Benzo(ghi)perylene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Benzo(k)fluoranthene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Butyl benzyl phthalate	5.500E-01	1.00E-06	1490	2.77	0.25	48	15	27	5475	2.764E-06
Carbazole	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Chrysene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Di-n-butyl phthalate	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Fluoranthene	5.500E-01	1.00E-06	1490	2.77	0.25	48	15	27	5475	2.764E-06
Indeno(1,2,3-c,d)pyrene	1.150E+00	1.00E-06	1490	2.77	0.25	48	15	27	5475	5.779E-06
Lead	1.770E+02	1.00E-06	1490	2.77	0.01	48	15	27	5475	3.558E-05
Phenanthrene	5.500E-01	1.00E-06	1490	2.77	0.25	48	15	27	5475	2.764E-06
Pyrene	5.500E-01	1.00E-06	1490	2.77	0.25	48	15	27	5475	2.764E-06
Selenium	2.300E+00	1.00E-06	1490	2.77	0.01	48	15	27	5475	4.624E-07

TABLE U-4 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SEDIMENT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Anthracene	1.150E+00	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.667E-06
Benzo(a)anthracene	1.150E+00	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.667E-06
Benzo(a)pyrene	1.150E+00	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.667E-06
Benzo(b)fluoranthene	1.150E+00	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.667E-06
Benzo(ghi)perylene	1.150E+00	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.667E-06
Benzo(k)fluoranthene	1.150E+00	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.667E-06
Butyl benzyl phthalate	5.500E-01	1.0E-06	3120	2.77	0.25	48	25	70	25550	7.973E-07
Carbazole	1.150E+00	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.667E-06
Chrysene	1.150E+00	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.667E-06
Di-n-butyl phthalate	1.150E+00	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.667E-06
Fluoranthene	5.500E-01	1.0E-06	3120	2.77	0.25	48	25	70	25550	7.973E-07
Indeno(1,2,3-c,d)pyrene	1.150E+00	1.0E-06	3120	2.77	0.25	48	25	70	25550	1.667E-06
Lead	1.770E+02	1.0E-06	3120	2.77	0.01	48	25	70	25550	1.026E-05
Phenanthrene	5.500E-01	1.0E-06	3120	2.77	0.25	48	25	70	25550	7.973E-07
Pyrene	5.500E-01	1.0E-06	3120	2.77	0.25	48	25	70	25550	7.973E-07
Selenium	2.300E+00	1.0E-06	3120	2.77	0.01	48	25	70	25550	1.334E-07

U-6

TABLE U-5 DAILY INTAKE - CHILD
DERMAL CONTACT WITH SEDIMENT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Anthracene	1.150E+00	1.0E-06	1490	2.77	0.25	48	15	27	25550	1.238E-06
Benzo(a)anthracene	1.150E+00	1.0E-06	1490	2.77	0.25	48	15	27	25550	1.238E-06
Benzo(a)pyrene	1.150E+00	1.0E-06	1490	2.77	0.25	48	15	27	25550	1.238E-06
Benzo(b)fluoranthene	1.150E+00	1.0E-06	1490	2.77	0.25	48	15	27	25550	1.238E-06
Benzo(ghi)perylene	1.150E+00	1.0E-06	1490	2.77	0.25	48	15	27	25550	1.238E-06
Benzo(k)fluoranthene	1.150E+00	1.0E-06	1490	2.77	0.25	48	15	27	25550	1.238E-06
Butyl benzyl phthalate	5.500E-01	1.0E-06	1490	2.77	0.25	48	15	27	25550	5.923E-07
Carbazole	1.150E+00	1.0E-06	1490	2.77	0.25	48	15	27	25550	1.238E-06
Chrysene	1.150E+00	1.0E-06	1490	2.77	0.25	48	15	27	25550	1.238E-06
Di-n-butyl phthalate	1.150E+00	1.0E-06	1490	2.77	0.25	48	15	27	25550	1.238E-06
Fluoranthene	5.500E-01	1.0E-06	1490	2.77	0.25	48	15	27	25550	5.923E-07
Indeno(1,2,3-c,d)pyrene	1.150E+00	1.0E-06	1490	2.77	0.25	48	15	27	25550	1.238E-06
Lead	1.770E+02	1.0E-06	1490	2.77	0.01	48	15	27	25550	7.625E-06
Phenanthrene	5.500E-01	1.0E-06	1490	2.77	0.25	48	15	27	25550	5.923E-07
Pyrene	5.500E-01	1.0E-06	1490	2.77	0.25	48	15	27	25550	5.923E-07
Selenium	2.300E+00	1.0E-06	1490	2.77	0.01	48	15	27	25550	9.908E-08

TABLE U-6 EXPOSURE ASSESSMENT PARAMETERS - SEDIMENT INGESTION
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	RECREATIONAL ADULT	RECREATIONAL CHILD
Ingestion Rate (mg/day)	100	200
Fraction Ingested from Contaminated Sources (unitless)	1	1
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	6
Body Weight (kilograms)	70	15
Conversion Factor	1E-06	1E-06
Averaging Times (years)		
Carcinogens	70	70
Noncarcinogens	25	6

TABLE U-7 DAILY INTAKE - ADULT
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Anthracene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Benzo(a)anthracene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Benzo(a)pyrene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Benzo(b)fluoranthene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Benzo(ghi)perylene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Benzo(k)fluoranthene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Butyl benzyl phthalate	5.500E-01	1E-06	100	1	48	25	70	9125	1.033E-07
Carbazole	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Chrysene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Di-n-butyl phthalate	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Fluoranthene	5.500E-01	1E-06	100	1	48	25	70	9125	1.033E-07
Indeno(1,2,3-c,d)pyrene	1.150E+00	1E-06	100	1	48	25	70	9125	2.160E-07
Lead	1.770E+02	1E-06	100	1	48	25	70	9125	3.325E-05
Phenanthrene	5.500E-01	1E-06	100	1	48	25	70	9125	1.033E-07
Pyrene	5.500E-01	1E-06	100	1	48	25	70	9125	1.033E-07
Selenium	2.300E+00	1E-06	100	1	48	25	70	9125	4.321E-07

U-8

TABLE U-8 DAILY INTAKE - CHILD
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL CHILD

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Adult Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Anthracene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Benzo(a)anthracene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Benzo(a)pyrene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Benzo(b)fluoranthene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Benzo(ghi)perylene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Benzo(k)fluoranthene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Butyl benzyl phthalate	5.500E-01	1E-06	200	1	48	6	15	2190	9.644E-07
Carbazole	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Chrysene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Di-n-butyl phthalate	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Fluoranthene	5.500E-01	1E-06	200	1	48	6	15	2190	9.644E-07
Indeno(1,2,3-c,d)pyrene	1.150E+00	1E-06	200	1	48	6	15	2190	2.016E-06
Lead	1.770E+02	1E-06	200	1	48	6	15	2190	3.104E-04
Phenanthrene	5.500E-01	1E-06	200	1	48	6	15	2190	9.644E-07
Pyrene	5.500E-01	1E-06	200	1	48	6	15	2190	9.644E-07
Selenium	2.300E+00	1E-06	200	1	48	6	15	2190	4.033E-06

TABLE U-9 DAILY INTAKE - ADULT
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Adult Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Anthracene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Benzo(a)anthracene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Benzo(a)pyrene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Benzo(b)fluoranthene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Benzo(ghi)perylene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Benzo(k)fluoranthene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Butyl benzyl phthalate	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Carbazole	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Chrysene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Di-n-butyl phthalate	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Fluoranthene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Indeno(1,2,3-c,d)pyrene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Lead	1.770E+02	1E-06	100	1	48	25	70	25550	1.188E-05
Phenanthrene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Pyrene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Selenium	2.300E+00	1E-06	100	1	48	25	70	25550	1.543E-07
Fluoranthene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Indeno(1,2,3-c,d)pyrene	1.150E+00	1E-06	100	1	48	25	70	25550	7.716E-08
Lead	1.770E+02	1E-06	100	1	48	25	70	25550	1.188E-05
Phenanthrene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Pyrene	5.500E-01	1E-06	100	1	48	25	70	25550	3.690E-08
Selenium	2.300E+00	1E-06	100	1	48	25	70	25550	1.543E-07

TABLE U-10 DAILY INTAKE - CHILD
SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL CHILD

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Anthracene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Benzo(a)anthracene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Benzo(a)pyrene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Benzo(b)fluoranthene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Benzo(ghi)perylene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Benzo(k)fluoranthene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Butyl benzyl phthalate	5.500E-01	1E-06	200	1	48	6	15	25550	8.266E-08
Carbazole	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Chrysene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Di-n-butyl phthalate	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Fluoranthene	5.500E-01	1E-06	200	1	48	6	15	25550	8.266E-08
Indeno(1,2,3-c,d)pyrene	1.150E+00	1E-06	200	1	48	6	15	25550	1.728E-07
Lead	1.770E+02	1E-06	200	1	48	6	15	25550	2.660E-05
Phenanthrene	5.500E-01	1E-06	200	1	48	6	15	25550	8.266E-08
Pyrene	5.500E-01	1E-06	200	1	48	6	15	25550	8.266E-08
Selenium	2.300E+00	1E-06	200	1	48	6	15	25550	3.457E-07
Phenanthrene	5.500E-01	1E-06	200	1	48	6	15	25550	8.266E-08
Pyrene	5.500E-01	1E-06	200	1	48	6	15	25550	8.266E-08
Selenium	2.300E+00	1E-06	200	1	48	6	15	25550	3.457E-07

TABLE U-11 EXPOSURE ASSESSMENT PARAMETERS - FISH INGESTION
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Fraction of Fish Ingested, unitless	0.5	0.5
Ingestion rate kg/day	0.054	0.043
Exposure Frequency days/yr	26	26
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE U-12 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical * Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.700E-04	0.054	26	0.5	25	70	9125	4.671E-09

* Concentration adjusted from surface water concentration to fish concentration by bioconcentration factor of 17

TABLE U-13 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical * Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.700E-04	0.043	26	0.5	15	27	5475	9.643E-09

* Concentration adjusted from surface water concentration to fish concentration by bioconcentration factor of 17

TABLE U-14 DAILY INTAKE - ADULT
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical * Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.700E-04	0.054	26	0.5	25	70	25550	1.668E-09

* Concentration adjusted from surface water concentration to fish concentration by bioconcentration factor of 17

TABLE U-15 DAILY INTAKE - CHILD
FISH INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (kg/day)	Exposure Frequency (days/year)	Fraction Ingested (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.700E-04	0.043	26	0.5	15	27	25550	2.066E-09

* Concentration adjusted from surface water concentration to fish concentration by bioconcentration factor of 17

TABLE U-16 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF SURFACE WATER
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Exposure Time (hrs/day)	2.6	2.6
Surface Water Contact Rate (ml/hr)	50	50
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE U-17 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.000E-05	0.050	48	2.6	25	70	9125	2.442E-09

TABLE U-18 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.000E-05	0.050	48	2.6	15	27	5475	6.332E-09

TABLE U-19 DAILY INTAKE - ADULT
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.000E-05	0.050	48	2.6	25	70	25550	8.722E-10

TABLE U-20 DAILY INTAKE - CHILD
SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Contact Rate (L/day)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	1.000E-05	0.050	48	2.6	15	27	25550	1.357E-09

TABLE U-21 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH THUNDERBAY RIVER SURFACE WATER
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	2.6	2.6
Dermal Permeability Constant	0.00084	0.00084
Exposure Frequency (days/year)	48	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	0.001

TABLE U-22 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	(b)	1.000E-05	0.022	19400	48	2.6	25	70	9125	0.001	2.085E-08

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

TABLE U-23 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	(b)	1.000E-05	0.022	13300	48	2.6	15	27	5475	0.001	3.705E-08

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

TABLE U-24 DAILY INTAKE - ADULT
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	(b)	1.000E-05	0.022	19400	48	2.6	25	70	25550	0.001	7.445E-09

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

TABLE U-25 DAILY INTAKE - CHILD
SURFACE WATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/kg)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Carbon Tetrachloride	(b)	1.000E-05	0.022	13300	48	2.6	15	27	25550	0.001	7.940E-09

(b) Predicted PC (Table 5-7 of U.S. EPA, 1992a).

TABLE U-26 CANCER ESTIMATE - SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT AND CHILD

Carcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence / Relative Potency Factor	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Anthracene	7.716E-08	1.728E-07	NO	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Benzo(a)anthracene	7.716E-08	1.728E-07	NO	7.3	B2 / 0.1	Liver and Lung	(a)	6E-08		1E-07	
Benzo(a)pyrene	7.716E-08	1.728E-07	NO	7.3	B2 /1.0	Fore Stomach	(a)	6E-07		1E-06	
Benzo(b)fluoranthene	7.716E-08	1.728E-07	NO	7.3	B2 /0.1	Lung, thorax, Liver	(a)	6E-08		1E-07	
Benzo(ghi)perylene	7.716E-08	1.728E-07	NO	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Benzo(k)fluoranthene	7.716E-08	1.728E-07	NO	7.3	B2 / 0.01	Lung, thorax, liver	(a)	6E-09		1E-08	
Butyl benzyl phthalate	3.690E-08	8.266E-08	NO	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Carbazole	7.716E-08	1.728E-07	NO	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Chrysene	7.716E-08	1.728E-07	NO	7.3	B2 /0.001	Liver, lung	(a)	6E-10		1E-09	
Di n-butyl phthalate	7.716E-08	1.728E-07	NO	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Fluoranthene	3.690E-08	8.266E-08	NO	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Indeno(1,2,3-c,d)pyrene	7.716E-08	1.728E-07	NO	7.3	B2/ 0.1	NA	(a)	6E-08		1E-07	
Lead	1.188E-05	2.660E-05	NO	NO DATA	NA	NA	NA	0E+00		0E+00	
Phenanthrene	3.690E-08	8.266E-08	NO	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Pyrene	3.690E-08	8.266E-08	NO	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
Selenium	1.543E-07	3.457E-07	NO	NO EVIDENCE	NA	NA	NA	0E+00		0E+00	
								0E+00		0E+00	
Total									7E-07		2E-06

TABLE U-27 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SEDIMENT INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT AND CHILD

Noncarcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	Chronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Anthracene	2.16E-07	2.02E-06	NO	0.3	No observed effects	IRIS 93	1	7E-07		7E-06	
Benzo(a)anthracene	2.16E-07	2.02E-06	NO	0.03	NA	(a)	1	7E-06		7E-05	
Benzo(a)pyrene	2.16E-07	2.02E-06	NO	0.03	NA	(a)	1	7E-06		7E-05	
Benzo(b)fluoranthene	2.16E-07	2.02E-06	NO	0.03	NA	(a)	1	7E-06		7E-05	
Benzo(ghi)perylene	2.16E-07	2.02E-06	NO	0.03	NA	(a)	1	7E-06		7E-05	
Benzo(k)fluoranthene	2.16E-07	2.02E-06	NO	0.03	NA	(a)	1	7E-06		7E-05	
Butyl benzyl phthalate	1.03E-07	9.64E-07	NO	NOT AVAILABLE	NA	NA	NA				
Carbazole	2.16E-07	2.02E-06	NO	NOT AVAILABLE	NA	NA	NA				
Chrysene	2.16E-07	2.02E-06	NO	NA	NA						
Di-n-butyl phthalate	2.16E-07	2.02E-06	NO	0.1	Increased mortality	IRIS 93	1	2E-06		2E-05	
Fluoranthene	1.03E-07	9.64E-07	NO	0.04	Neophropathy	IRIS 93	1	3E-06		2E-05	
Indeno(1,2,3-c,d)pyrene	2.16E-07	2.02E-06	NO	0.03	NA	(a)	NA	7E-06		7E-05	
Lead	3.33E-05	3.10E-04	NO	NO DATA	NA	NA	NA				
Phenanthrene	1.03E-07	9.64E-07	NO	0.03	NA	(a)	NA	3E-06		3E-05	
Pyrene	1.03E-07	9.64E-07	NO	0.03	NA	(a)	NA	3E-06		3E-05	
Selenium	4.32E-07	4.03E-06	NO	0.005	Clinical Scelnosis	IRIS 93	NA	9E-05		8E-04	
Total									1E-04		1E-03

(a) Chronic RfD for pyrene was used. Source IRIS 93

TABLE U-28 CANCER ESTIMATE - DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Carcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Adult Total Pathway Risk	Child Chemical Specific Risk	Child Total Pathway Risk
Anthracene	1.667E-06	1.238E-06	YES	NO EVIDENCE	NA	NA	NA	0.000E+00		0.000E+00	
Benzo(a)anthracene	1.667E-06	1.238E-06	YES	43	B2 / 0.1	Liver and Lung	(a)	7.169E-06		5.325E-06	
Benzo(a)pyrene	1.667E-06	1.238E-06	YES	43	B2 /1.0	Fore Stomach	(a)	7.169E-05		5.325E-05	
Benzo(b)fluoranthene	1.667E-06	1.238E-06	YES	43	B2 /0.1	Lung, thorax, Liver	(a)	7.169E-06		5.325E-06	
Benzo(ghi)perylene	1.667E-06	1.238E-06	YES	NO EVIDENCE	NA	NA	NA	7.169E-05		5.325E-05	
Benzo(k)fluoranthene	1.667E-06	1.238E-06	YES	43	B2 / 0.01	Lung, thorax, liver	(a)	7.169E-07		5.325E-07	
Butyl benzyl phthalate	7.973E-07	5.923E-07	YES	NO EVIDENCE	NA	NA	NA	3.428E-05		2.547E-05	
Carbazole	1.667E-06	1.238E-06	YES		NA	NA	NA	0.000E+00		0.000E+00	
Chrysene	1.667E-06	1.238E-06	YES	11	B2 /0.001	Liver, lung	(a)	1.834E-08		1.362E-08	
Di-n-butyl phthalate	1.667E-06	1.238E-06	YES	NO EVIDENCE	NA	NA	NA	0.000E+00		0.000E+00	
Fluoranthene	7.973E-07	5.923E-07	YES	NO EVIDENCE	NA	NA	NA	0.000E+00		0.000E+00	
Indeno(1,2,3-c,d)pyrene	1.667E-06	1.238E-06	YES	43	B2/ 0.1	NA	(a)	7.169E-06		5.325E-06	
Lead	1.026E-05	7.625E-06	YES	NO DATA	NA	NA	NA	0.000E+00		0.000E+00	
Phenanthrene	7.973E-07	5.923E-07	YES	NO EVIDENCE	NA	NA	NA	0.000E+00		0.000E+00	
Pyrene	7.973E-07	5.923E-07	YES	NO EVIDENCE	NA	NA	NA	0.000E+00		0.000E+00	
Selenium	1.334E-07	9.908E-08	YES	NO EVIDENCE	NA	NA	NA	0.000E+00			
Total									2E-04		1E-04

a) SF for pyrene used for all PAHs.
Adjusted from administered to absorberd dose assuming oral absorption efficiencies Chrysene 0.67(ASTDR, 1990), all PAHs 0.17 (ASTDR 1990), di-n-butyl phthalate 0.8 (ASTDR 1990),Se 0.935 (ASTDR 1989)

TABLE U-29 CANCER ESTIMATE - DERMAL CONTACT WITH SEDIMENTS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD * (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Anthracene	4.668E-06	5.779E-06	YES	0.05	No observed effects	IRIS 93	1	9.336E-05		1.156E-04	
Benzo(a)anthracene	4.668E-06	5.779E-06	YES	0.005	NA	(a)	1	9.336E-04		1.156E-03	
Benzo(a)pyrene	4.668E-06	5.779E-06	YES	0.005	NA	(a)	1	9.336E-04		1.156E-03	
Benzo(b)fluoranthene	4.668E-06	5.779E-06	YES	0.005	NA	(a)	1	9.336E-04		1.156E-03	
Benzo(ghi)perylene	4.668E-06	5.779E-06	YES	0.005	NA	(a)	1	9.336E-04		1.156E-03	
Benzo(k)fluoranthene	4.668E-06	5.779E-06	YES	0.005	NA	(a)	1	9.336E-04		1.156E-03	
Butyl benzyl phthalate	2.232E-06	2.764E-06	YES	0.005	NA	NA	NA	4.465E-04		5.528E-04	
Carbazole	4.668E-06	5.779E-06	YES		NA	NA	NA				
Chrysene	4.668E-06	5.779E-06	YES	0.02	NA	NA		2.334E-04		2.890E-04	
Di-n-butyl phthalate	4.668E-06	5.779E-06	YES	0.08	Increased mortality	IRIS 93	1	5.835E-05		7.224E-05	
Fluoranthene	2.232E-06	2.764E-06	YES	0.007	Neophropathy	IRIS 93	1	3.189E-04		3.949E-04	
Indeno(1,2,3-c,d)pyrene	4.668E-06	5.779E-06	YES	0.005	NA	(a)	NA	9.336E-04		1.156E-03	
Lead	2.874E-05	3.558E-05	YES	NO DATA	NA	NA	NA				
Phenanthrene	2.232E-06	2.764E-06	YES	0.005	NA	(a)	NA	4.465E-04		5.528E-04	
Pyrene	2.232E-06	2.764E-06	YES	0.005	NA	(a)	NA	4.465E-04		5.528E-04	
Selenium	3.734E-07	4.624E-07	YES	0.005	Clinical Scelnosis	IRIS 93	NA	7.469E-05		9.247E-05	
Total									7.720E-03		9.558E-03

Adjusted from administered to absorberd dose assuming oral absorption efficiencies Chrysene 0.67(ASTDR, 1990), all PAHs 0.17 (ASTDR, 1990), di-n-butyl phthalate 0.8 (ASTDR 1990),Se 0.935 (ASTDR 1989)
a) Chronic RfD for pyrene used for all PAHs.

TABLE U-30 CANCER ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption (mg/kg-day)	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Carbon Tetrachloride	1.668E-09	2.066E-09	NO	0.13	B2	heptocellular carcinomas	IRIS, 1993	2.169E-10		2.686E-10	
Total									2.169E-10		2.686E-10

TABLE U-31 CHRONIC HAZARDOUS INDEX ESTIMATE - FISH INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Carbon Tetrachloride	4.671E-09	9.643E-09	NO	0.0007	Liver	IRIS, 1993	1	6.673E-06		1.378E-05	
									6.673E-06		1.378E-05

TABLE U-32 CANCER ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult -CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Carbon Tetrachloride	8.722E-10	1.357E-09	NO	0.13	B2	heptocellular carcinomas	IRIS, 1993	1.134E-10		1.764E-10	
									1.134E-10		1.764E-10

TABLE U-33 CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Carbon Tetrachloride	2.442E-09	6.332E-09	NO	0.0007	Liver	IRIS, 1993	1	3.489E-06		9.045E-06	
									3.489E-06		9.045E-06

TABLE U-34 CANCER ESTIMATE - SURFACE WATER DERMAL
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF * (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Carbon Tetrachloride	7.445E-09	7.940E-09	YES	1.44E-01	B2	heptocellular carcinomas	IRIS, 1993	1.075E-09		1.147E-09	
Total									1.075E-09		1.147E-09

* Adjusted from administered to absorbed dose using and efficiency of 0.90 (ATDSR,1992).

TABLE U-35 CHRONIC HAZARDOUS INDEX ESTIMATE - SURFACE WATER DERMAL
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 6 & 7, Former Solid Waste Landfill and First Fire Training Area, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI * Adjusted for Absorption	RfD * (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Carbon Tetrachloride	2.085E-08	3.705E-08	YES	0.00063	Liver	IRIS, 1993	1	3.309E-05		5.882E-05	
									3.309E-05		5.882E-05

* Adjusted from administered to absorbed dose using and efficiency of 0.90 (ATDSR,1992).

Groundwater Solute Transport Model Data - Site 6/7

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.

2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.

3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.

4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.

5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.

6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft^2/day at TF4-MW3 to 15,290 ft^2/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^{n} (h_m - h_s)_i^2]^{0.5}$$

n = number of wells
h_m = measured head
h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = 128.78/38 = 3.3891
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

* The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).

* The initial head data input to the transport model are results of measurements taken in September 1993.

* Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.

* Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.

* The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.

* The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 6

Carbon Tetrachloride was present in LF6MW3 above MDNR Type B cleanup criteria at a concentration of 1.2 ug/l. This data was input to the model and concentrations were monitored along the backwater area of Lake Winyah and at the sinkhole with respect to time.

Appendix V: Site 8 Risk Assessment

Table V-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 8
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-HN8	MW1	PC-HN8-MW1-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-HN8	MW2	PC-HN8-MW2-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-HN8	MW3	PC-HN8-MW3-GW4	GROUNDWATER	Tetrachloroethylene	1.2000
PC-HN8	MW4	PC-HN8-MW4-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-HN8	MW5	PC-HN8-MW5-GW4	GROUNDWATER	Tetrachloroethylene	0.1500

Table V-2A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Soil - Site 8
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	SAMPLE DEPTH RANGE		RESULT
PC-HN8	SB4	PC-HN8-SB4-SS00-02	SOIL	Antimony	0.0000	2.0000	2.3500
PC-HN8	SB6	PC-HN8-SB6-SS00-02	SOIL	Antimony	0.0000	2.0000	5.1000
PC-HN8	SB7	PC-HN8-SB7-SS00-02	SOIL	Antimony	0.0000	2.0000	2.4000
PC-HN8	SB4	PC-HN8-SB4-SS00-02	SOIL	Lead	0.0000	2.0000	2.2000
PC-HN8	SB6	PC-HN8-SB6-SS00-02	SOIL	Lead	0.0000	2.0000	42.6000

TABLE V-1 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF GROUNDWATER
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

PARAMETER	RECREATIONAL ADULT	RECREATIONAL CHILD
Ingestion Rate (L/day)	2	2
Exposure Frequency (days/year)	298 *	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

*Worst case scenario assumes that the adult is present on-site 250 days /year as a worker and 48 days per year for recreation

TABLE V-2 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	8.077E-04	2	298	25	70	9125	1.884E-05

TABLE V-3 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	8.077E-04	2	48	15	27	5475	7.868E-06

TABLE V-4 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	8.077E-04	2	298	25	70	25550	6.729E-06

TABLE V-5 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	8.077E-04	2	48	15	27	25550	1.686E-06

TABLE V-6 EXPOSURE ASSESSMENT PARAMETERS - INHALATION OF GROUNDWATER
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

PARAMETER	RECREATIONAL ADULT	RECREATIONAL CHILD
Exposure TIme (hours/day)	0.12	0.12
Inhalation Rate (cu m/hr)	0.6	0.6
Exposure Frequency (days/yr)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

*Worst case scenario assumes that the adult is present on-site 250 days /year as a worker and 48 days per year for recreation

TABLE V-7 DAILY INTAKE - ADULT
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	7.630E-03	0.6	298	0.12	25	70	9125	6.407E-06

TABLE V-8 DAILY INTAKE - CHILD
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	7.630E-03	0.6	48	0.12	15	27	5475	2.676E-06

TABLE V-9 DAILY INTAKE - ADULT
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	7.630E-03	0.6	298	0.12	25	70	25550	2.288E-06

TABLE V-10 DAILY INTAKE - CHILD
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	7.630E-03	0.6	48	0.12	15	27	25550	5.734E-07

TABLE V-11 GROUNDWATER INHALATION MODEL CALCULATIONS
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemicals	Chemical Concentration (mg/L)	Fraction Volatilized (unitless)	Water Flow Rate (L/hr)	Showering Duration Period (hr)	Post Showering Duration Period (hr)	Bathroom Volume (cu m)	Showering Maximum Contaminant Concn'n in Air (mg/cu m)	During and After Showering MAX Contaminant Concn'n in Air (mg/cu m)
Tetrachloroethylene	8.077E-04	0.7	750	0.25	0.35	11	9.638E-03	7.630E-03

TABLE V-12 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH GROUNDWATER
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

PARAMETER	RECREATIONAL ADULT	RECREATIONAL CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	0.25	0.25
Dermal Permeability Constant *	0.00084 *	0.00084 *
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	

*Worst case scenario assumes that the adult is present on-site 250 days /year as a worker and 48 days per year for recreation

TABLE V-13 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	*	Chemical Concentration (mg/l)	* Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a)	8.077E-04	0.4	19400	298	0.25	25	70	9125	0.001	1.828E-05

* (a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992).

TABLE V-14 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	*	Chemical Concentration (mg/l)	* Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a)	8.077E-04	0.4	13300	48	0.25	15	27	5475	0.001	5.232E-06

* (a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992).

TABLE V-15 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	*	Chemical Concentration (mg/l)	* Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a)	8.077E-04	0.4	19400	298	0.25	25	70	25550	0.001	6.527E-06

* (a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992).

TABLE V-16 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	*	Chemical Concentration (mg/l)	* Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a)	8.077E-04	0.4	13300	48	0.25	15	27	25550	0.001	1.121E-06

* (a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992).

TABLE V-17 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH SOILS
Site 8, Former Site of Hangar 8, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER	ON-SITE ADULT	RECREATIONAL ADULT	RECREATIONAL CHILD
Skin Surface Area Available for Contact (cm^2/day)	3120	3120	3120	1490
Soil to Skin Adherence Factor (mg/cm^2)	2.77	2.77	2.77	2.77
Absorption Factor, Unitless				
Metals	0.01	0.01	0.01	0.01
Organics	0.25	0.25	0.25	0.25
Exposure Factor (days/year)	250	250	298	48
Exposure Duration (year)	0.08	25	25	15
Body Weight (kilograms)	70	70	70	27
Conversion Factor	1E-06	1E-06	1E-06	
Averaging Time, years				
Carcinogens	70	70	70	70
Noncarcinogens	0.08	25	25	15

Recreational adult assumes the adult works at the recreational area 250 days/yr and participates in recreation another 48 days per year.

TABLE V-18 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
CURRENT LAND USE SCENARIO - ON-SITE EMPLOYEE

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.00E-06	3120	2.77	0.01	250	25	70	9125	4.313E-06
Lead	4.260E+01	1.00E-06	3120	2.77	0.01	250	25	70	9125	3.602E-05

TABLE V-19 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
CURRENT LAND USE SCENARIO - ON-SITE EMPLOYEE

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.0E-06	3120	2.77	0.01	250	25	70	25550	1.540E-06
Lead	4.260E+01	1.0E-06	3120	2.77	0.01	250	25	70	25550	1.287E-05

TABLE V-20 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncardinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.00E-06	3120	2.77	0.01	250	0.08	70	29.2	4.313E-06
Lead	4.260E+01	1.00E-06	3120	2.77	0.01	250	0.08	70	29.2	3.602E-05

TABLE V-21 DAILY INTAKE - ADULT
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.0E-06	3120	2.77	0.01	250	0.08	70	25550	4.929E-09
Lead	4.260E+01	1.0E-06	3120	2.77	0.01	250	0.08	70	25550	4.117E-08

TABLE V-22 DAILY INTAKE - ADULTS
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.00E-06	3120	2.77	0.01	298	25	70	9125	5.141E-06
Lead	4.260E+01	1.00E-06	3120	2.77	0.01	298	25	70	9125	4.294E-05

TABLE V-23 DAILY INTAKE CHILD
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - RECREATIONAL CHILD

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.00E-06	1490	2.77	0.01	48	15	27	5475	1.025E-06
Lead	4.260E+01	1.00E-06	1490	2.77	0.01	48	15	27	5475	8.564E-06

TABLE V-24 DAILY INTAKE - ADULTS
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.0E-06	3120	2.77	0.01	298	25	70	25550	1.836E-06
Lead	4.260E+01	1.0E-06	3120	2.77	0.01	298	25	70	25550	1.534E-05

TABLE V-25 DAILY INTAKE CHILD
DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Factor (kg/mg)	Available Skin Surface (cm^2/day)	Soil to Skin Adherence (mg/cm^2)	Absorption Factor (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Absorbed Dose (mg/kg-day)
Antimony	5.100E+00	1.0E-06	1490	2.77	0.01	48	15	27	25550	2.197E-07
Lead	4.260E+01	1.0E-06	1490	2.77	0.01	48	15	27	25550	1.835E-06

TABLE V-20 EXPOSURE ASSESSMENT PARAMETERS - SOIL INGESTION
Site 8, Former Site of Hangar 8, Alpena CRTC, Alpena, MI

PARAMETER	FACILITY EMPLOYEE	EXCAVATION WORKER	RECREATIONAL ADULT	RECREATIONAL CHILD
Ingestion Rate (mg/day)	100	480	100	200
Fraction Ingested from Contaminated Sources (unitless)	1	1	1	1
Exposure Frequency (days/year)	250	250	298	48
Exposure Duration (years)	25	0.08	25	6
Body Weight (kilograms)	70	70	70	15
Conversion Factor	1E-06	1E-06	1E-06	1E-06
Averaging Time, years				
Carcinogens	70	70	70	70
Noncarcinogens	25	0.08	25	6

Recreational adult assumes the adult works at the recreational area 250 days/yr and participates in recreation another 48 days per year.

TABLE V-27 DAILY INTAKE - ADULT
SOIL INGESTION
CURRENT LAND USE SCENARIO -FACILITY EMPLOYEE

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E+00	1E-06	100	1	250	25	70	9125	4.990E-06
Lead	4.260E+01	1E-06	100	1	250	25	70	9125	4.168E-05

TABLE V-28 DAILY INTAKE - ADULT
SOIL INGESTION
CURRENT LAND USE SCENARIO - FACILITY EMPLOYEE

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E+00	1E-06	100	1	250	25	70	25550	1.782E-06
Lead	4.260E+01	1E-06	100	1	250	25	70	25550	1.489E-05

TABLE V-20 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E+00	1E-06	480	1	250	0.08	70	29.2	2.395E-05
Lead	4.260E+01	1E-06	480	1	250	0.08	70	29.2	2.001E-04

TABLE V-30 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E+00	1E-06	480	1	250	0.08	70	25550	2.737E-08
Lead	4.260E+01	1E-06	480	1	250	0.08	70	25550	2.287E-07

TABLE V-31 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E+00	1E-06	100	1	298	25	70	9125	5.948E-06
Lead	4.260E+01	1E-06	100	1	298	25	70	9125	4.969E-05

TABLE V-32 DAILY INTAKE - CHILD
SOIL INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL CHILD

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E+00	1E-06	200	1	48	6	15	2190	8.942E-06
Lead	4.260E+01	1E-06	200	1	48	6	15	2190	7.470E-05

TABLE V-33 DAILY INTAKE - ADULT
SOIL INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL ADULT

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E+00	1E-06	100	1	298	25	70	25550	2.124E-06
Lead	4.260E+01	1E-06	100	1	298	25	70	25550	1.775E-05

TABLE V-34 DAILY INTAKE - CHILD
SOIL INGESTION
FUTURE LAND USE SCENARIO - RECREATIONAL CHILD

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Conversion Rate	Ingestion Rate (mg/day)	Fraction Ingested (unitless)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Average Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E+00	1E-06	200	1	48	6	15	25550	7.665E-07
Lead	4.260E+01	1E-06	200	1	48	6	15	25550	6.403E-06

TABLE V-35 EXPOSURE ASSESSMENT PARAMETERS - SOIL INHALATION
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

PARAMETER	EXCAVATION WORKER
Inhalation Rate, (mg/cu m)	20
Exposure Time (hours/day)	8
Exposure Frequency (days/year)	250
Exposure Duration (years)	0.08
Body Weight (kilograms)	70
Averaging Time (years)	
Carcinogens	70
Noncarcinogens	0.08

TABLE V-36 DAILY INTAKE - ADULT
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Noncarcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E-05	0.08	20	8	250	70	29.2	7.984E-05
Lead	4.260E-04	0.08	20	8	250	70	29.2	6.669E-04

TABLE V-37 DAILY INTAKE - ADULT
SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKERS

Carcinogenic Effect Exposure Assessment
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Concentration (mg/cu m)	Exposure Duration (years)	Inhalation Rate (cu m/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Weight (kg)	Time (days)	Intake Rate (mg/kg-day)
Antimony	5.100E-05	0.08	20	8	250	70	25550	9.125E-08
Lead	4.260E-04	0.08	20	8	250	70	25550	7.622E-07

TABLE V-38 SOIL INHALATION MODEL CALCULATIONS
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Construction work		
Dust Loading Factor (g/m^3)	600	g/m^3
Conversion Factor	0.001	mg/g
Computations	Antimony	Lead
C(i), mg/kg	5.1	42.6
W(i)/W, g/g	5.1E-05	4.26E-04
C(air), mg/m^3	3.06E-05	2.56E-04

TABLE V-39 SOIL INHALTION MODEL CALCULATIONS
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Construction traffic		
Dust Loading Factor (g/m^3)	400	g/m^3
Conversion Factor	0.001	mg/g

Computations	Antimony	Lead
C(i), mg/kg	5.1	42.6
W(i)/W, g/g	5.1E-05	4.26E-04
C(air), mg/m^3	2.04E-05	1.70E-04

TABLE V-40 CANCER ESTIMATE - GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	6.729E-06	1.686E-06	NO	0.051	B2	Liver	CA EPA, 92	3E-07		9E-08	
Total									3E-07		9E-08

TABLE V-41 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	1.884E-05	7.868E-06	NO	0.01	Hepatotoxicity	IRIS, 1993	1	2E-03		8E-04	
Total									2E-03		8E-04

TABLE V-43 CANCER ESTIMATE - GROUNDWATER INHALATION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	2.288E-06	5.734E-07	NO	0.0018	B2	Leukemia, Liver	CA EPA, 92	4E-09		1E-09	
Total									4E-09		1E-09

TABLE V-44 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INHALATION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	6.407E-06	2.676E-06	NO	0.01	NA	NA	NA	6E-04		3E-04	
Total									6E-04		3E-04

1) RfD for corresponding chronic oral RfD use.

TABLE V-45 CANCER ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	6.527E-06	1.121E-06	YES	0.051	B2	Liver	CA EPA, 92	3E-07		6E-08	
Total									3E-07		6E-08

Adjusted from administered to absorbed using and absorption efficiency of 100%.

TABLE V-46 CHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD* (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	1.828E-05	5.232E-06	NO	0.01	Hepatotoxicity	IRIS, 1993	1	2E-03		5E-04	
Total									2E-03		5E-04

Adjusted from administered to absorbed using and absorption efficiency of 100%.

TABLE V-47 CANCER ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO

Carcinogenic Effects
Site 8, Former Site of Hanger 9, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	Recreational Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Excavation Chemical-Specific Risk	Total Pathway Risk	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Antimony	4.929E-09	1.816E-06	2.197E-07	YES	NO EVIDENCE				0E+00		0E+00		0E+00	
Lead	4.117E-08	1.534E-05	1.836E-06	YES	NO DATA	B2	Kidney		0E+00		0E+00		0E+00	
Total										0E+00		0E+00		0E+00

TABLE V-48 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SOILS
FUTURE LAND USE SCENARIO

Noncarcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD* (mg/kg-day)	Chronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Excavation Chemical-Specific Risk	Total Pathway Risk	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Antimony	4.313E-06	5.141E-06	1.025E-06	YES	2E-05	2E-05	Reduced Lifespan	IRIS 93	1	2E-01		3E-01		5E-02	
Lead	3.602E-05	4.294E-05	8.564E-06	YES	0.01	0.01	Liver	HEAST FY93	1	4E-03		4E-03		4E-03	
Total											2E-01		3E-01		5E-02

*RfD adjusted from administered to absorbed dose using an absorption efficiency of 5%.

TABLE V-40 CANCER ESTIMATE - DERMAL CONTACT WITH SOILS - ON-SITE EMPLOYEE
CURRENT LAND USE SCENARIO

Carcinogenic Effects
Site 8, Former Site of Hangar 8, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk
Antimony	1.540E-06	YES	NO EVIDENCE				0E+00	
Lead	1.287E-05	YES	NO DATA	B2	Kidney		0E+00	
Total								0E+00

TABLE V-50 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH SOILS - ON-SITE EMPLOYEE
CURRENT LAND USE SCENARIO

Noncarcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	CDI Adjusted for Absorption	Chronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk
Antimony	4.313E-06	YES	2E-05	Reduced Lifespan	IRIS 93	1	2E-01	
Lead	3.602E-05	YES	0.01	Liver	HEAST FY93	1	4E-03	
Total								2E-01

*RfD adjusted from administered to absorbed dose using an absorption efficiency of 5%.

TABLE V-81 CANCER ESTIMATE - SOIL INGESTION
FUTURE LAND USE SCENARIO

Carcinogenic Effects
Site B, Former Site of Hangar D, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	EXCAVATION Chemical-Specific Risk	ADULT Chemical-Specific Risk	CHILD Chemical-Specific Risk	Total Pathway Risk
Antimony	2.7ME-08	2.12ME-08	7.06E-07	NA	NO DATA				0E+00	0E+00	0E+00	
Lead	2.29E-07	1.77E-08	6.01E-08	NA	NO DATA	D	Kidney		0E+00	0E+00	0E+00	
Total									0E+00	0E+00	0E+00	

TABLE V-62. CHRONIC AND SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INGESTION
FUTURE LAND USE SCENARIO

Noncarcinogenic Effects
Site R, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Excavation Worker CDI (mg/kg-day)	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD (mg/kg-day)	Chronic SF	Critical Effect	RfD Source	Modifying Factor	EVALUATION Chemical-Specific Risk	Total Pathway Risk	ADULT Chemical-Specific Risk	Total Pathway Risk	CHILD Chemical-Specific Risk	Total Pathway Risk
Antimony	2.40E-05	5.14E-06	8.57E-06	NO	0.0004	0.0004	Reduced Lifespan	HEAST FY'94	1	0E-02		1E-02		2E-02	
Lead	2.00E-04	4.00E-05	7.47E-05	NO	NO DATA	NO DATA									
Total											0E-02		1E-02		2E-02

No subchronic RfD available as of 12/08/93. Chronic RfD used.

TABLE V-83 CANCER ESTIMATE - SOIL INGESTION
CURRENT LAND USE SCENARIO - FACILITY EMPLOYEE

Carcinogenic Effects
Site B, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	FACILITY EMPLOYEE CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)-1	Weight of Evidence	Type of Cancer	SF Source	ADULT Chemical-Specific Risk	Total Pathway Risk
Antimony	1.70E-00	NO	[illegible]				0E+00	
Lead	1.49E-05	NO	NO DATA	B2	Kidney		0E+00	
Total								0E+00

TABLE V-64 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INGESTION
CURRENT LAND USE SCENARIO - FACILITY EMPLOYEE

Noncarcinogenic Effects
Site B: Former Site of Hangar B, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	CDI Adjusted for Absorption	Chronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	ADULT Chemical-Specific Risk	Total Pathway Risk
Antimony	4.00E-03	NA	0.0004		HEAST FY93	1		
Lead	4.10E-05	NO	NO DATA	Reduced Lifespan		1	1E-02	
Total								1E-02

TABLE V-55 CANCER ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Carcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Excavation CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Excavation Chemical-Specific Risk	Total Pathway Risk
Antimony	9.125E-08	NO	NO EVIDENCE				0E+00	
Lead	7.622E-07	NO	NO DATA	B2	NA		0E+00	
Total								0E+00

TABLE V-56 SUBCHRONIC HAZARDOUS INDEX ESTIMATE - SOIL INHALATION
FUTURE LAND USE SCENARIO - EXCAVATION WORKER

Noncarcinogenic Effects
Site 8, Former Site of Hangar 9, Alpena CRTC, Alpena, MI

Chemical	Excavation CDI (mg/kg-day)	CDI Adjusted for Absorption	Subchronic RfD (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Excavation Chemical-Specific Risk	Total Pathway Risk
Antimony	7.984E-05	NO	0.0004	NA	IRIS 93	NA	2E-01	
Lead	6.669E-04	NO	NO DATA			NA		
Total								2E-01

* RfD converted for corresponding subchronic oral RfD was used.

Groundwater Solute Transport Model Data - Site 8

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.

2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.

3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.

4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.

5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.

6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft^2/day at TF4-MW3 to 15,290 ft^2/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^{n} (h_m - h_s)_i^2]^{0.5}$$

n = number of wells
h_m = measured head
h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = 128.78/38 = 3.3891
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

* The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).

* The initial head data input to the transport model are results of measurements taken in September 1993.

* Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.

* Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.

* The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.

* The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 8

PCE was present in well HN8MW8 above MDNR Type B cleanup criteria at a concentration of 1.2 ug/l. This data was input to the model and concentrations at the sinkhole were monitored with respect to time.

Appendix W: Site 9 Risk Assessment

Table W-1A
Data Utilized to Calculate Reasonable Maximum Exposure Concentrations for Groundwater - Site 9
MIANG, Alpena CRTC, Alpena, MI

SITE	LOCATOR	SAMPLE ID	MATRIX	ANALYTE	RESULT
PC-RT9	MW1	PC-RT9-MW1-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-RT9	MW2	PC-RT9-MW2-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-RT9	MW3	PC-RT9-MW3-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-RT9	MW4	PC-RT9-MW4-GW4	GROUNDWATER	1,4-Dichlorobenzene	0.0750
PC-RT9	MW6	PC-RT9-MW6-GW4	GROUNDWATER	1,4-Dichlorobenzene	18.0000
PC-RT9	MW1	PC-RT9-MW1-GW4	GROUNDWATER	2-Methylnaphthalene	2.5000
PC-RT9	MW2	PC-RT9-MW2-GW4	GROUNDWATER	2-Methylnaphthalene	2.5000
PC-RT9	MW3	PC-RT9-MW3-GW4	GROUNDWATER	2-Methylnaphthalene	2.5000
PC-RT9	MW4	PC-RT9-MW4-GW4	GROUNDWATER	2-Methylnaphthalene	2.5000
PC-RT9	MW5	PC-RT9-MW5-GW4	GROUNDWATER	2-Methylnaphthalene	2.5000
PC-RT9	MW6	PC-RT9-MW6-GW4	GROUNDWATER	2-Methylnaphthalene	47.0000
PC-RT9	MW1	PC-RT9-MW1-GW4	GROUNDWATER	Benzene	0.1750
PC-RT9	MW2	PC-RT9-MW2-GW4	GROUNDWATER	Benzene	0.1750
PC-RT9	MW3	PC-RT9-MW3-GW4	GROUNDWATER	Benzene	0.1750
PC-RT9	MW4	PC-RT9-MW4-GW4	GROUNDWATER	Benzene	0.1750
PC-RT9	MW5	PC-RT9-MW5-GW4	GROUNDWATER	Benzene	0.1750
PC-RT9	MW6	PC-RT9-MW6-GW4	GROUNDWATER	Benzene	3.9000
PC-RT9	MW1	PC-RT9-MW1-GW4	GROUNDWATER	Lead, Dissolved	1.0000
PC-RT9	MW2	PC-RT9-MW2-GW4	GROUNDWATER	Lead, Dissolved	1.0000
PC-RT9	MW3	PC-RT9-MW3-GW4	GROUNDWATER	Lead, Dissolved	1.0000
PC-RT9	MW4	PC-RT9-MW4-GW4	GROUNDWATER	Lead, Dissolved	1.0000
PC-RT9	MW5	PC-RT9-MW5-GW4	GROUNDWATER	Lead, Dissolved	1.0000
PC-RT9	MW6	PC-RT9-MW6-GW4	GROUNDWATER	Lead, Dissolved	15.9000
PC-RT9	MW1	PC-RT9-MW1-GW4	GROUNDWATER	Tetrachloroethylene	1.0000
PC-RT9	MW2	PC-RT9-MW2-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-RT9	MW3	PC-RT9-MW3-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-RT9	MW4	PC-RT9-MW4-GW4	GROUNDWATER	Tetrachloroethylene	1.7000
PC-RT9	MW5	PC-RT9-MW5-GW4	GROUNDWATER	Tetrachloroethylene	0.1500
PC-RT9	MW6	PC-RT9-MW6-GW4	GROUNDWATER	Tetrachloroethylene	1.5000

TABLE W-1 EXPOSURE ASSESSMENT PARAMETERS - INGESTION OF GROUNDWATER
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Ingestion Rate (L/day)	2	2.000
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE W-2 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.369E-03	2	298	25	70	9125	3.193E-05
2-Methylnaphthalene	2.486E-02	2	298	25	70	9125	5.799E-04
1,4-Dichlorobenzene	1.130E-02	2	298	25	70	9125	2.637E-04
Benzene	3.900E-03	2	298	25	70	9125	9.097E-05
Lead, Dissolved	8.487E-03	2	298	25	70	9125	1.980E-04

TABLE W-3 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.369E-03	2.000	48	15	27	5475	1.333E-05
2-Methylnaphthalene	2.486E-02	2.000	48	15	27	5475	2.422E-04
1,4-Dichlorobenzene	1.130E-02	2.000	48	15	27	5475	1.101E-04
Benzene	3.900E-03	2.000	48	15	27	5475	3.799E-05
Lead, Dissolved	8.487E-03	2.000	48	15	27	5475	8.268E-05

TABLE W-4 DAILY INTAKE - ADULT
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/l)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.369E-03	2	298	25	70	25550	1.140E-05
2-Methylnaphthalene	2.486E-02	2	298	25	70	25550	2.071E-04
1,4-Dichlorobenzene	1.130E-02	2	298	25	70	25550	9.417E-05
Benzene	3.900E-03	2	298	25	70	25550	3.249E-05
Lead, Dissolved	8.487E-03	2	298	25	70	25550	7.071E-05

TABLE W-5 DAILY INTAKE - CHILD
INGESTION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Chemical Concentration (mg/kg)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	1.369E-03	2.000	48	15	27	25550	2.857E-06
2-Methylnaphthalene	2.486E-02	2.000	48	15	27	25550	5.190E-05
1,4-Dichlorobenzene	1.130E-02	2.000	48	15	27	25550	2.359E-05
Benzene	3.900E-03	2.000	48	15	27	25550	8.141E-06
Lead, Dissolved	8.487E-03	2.000	48	15	27	25550	1.772E-05

TABLE W-6 CALCULATIONS FOR GROUNDWATER INHALATION
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemicals	Chemical Concentration (mg/L)	Fraction Volatilized (unitless)	Water Flow Rate (L/hr)	Showering Duration Period (hr)	Post Showering Duration Period (hr)	Bathroom Volume (cu m)	Showering Maximum Contaminant Concn'n in Air (mg/cu m)	During and After Showering MAX Contaminant Concn'n in Air (mg/cu m)
Tetrachloroethylene	1.369E-03	0.7	750	0.25	0.35	11	1.633E-02	1.293E-02
2-Methylnaphthalene	0.000E+00	0.7	750	0.25	0.35	11	0.000E+00	0.000E+00
1,4-Dichlorobenzene	1.130E-02	0.7	750	0.25	0.35	11	1.349E-01	1.068E-01
Benzene	2.047E-03	0.7	750	0.25	0.35	11	2.442E-02	1.933E-02
Lead, Dissolved	0.000E+00	0.7	750	0.25	0.35	11	0.000E+00	0.000E+00

TABLE W-7 EXPOSURE ASSESSMENT PARAMETERS - INHALATION OF GROUNDWATER
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Exposure Time (hours/day)	0.120	0.120
Inhalation Rate (cu m/hr)	0.600	0.600
Exposure Frequency (days/yr)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time (years)		
Carcinogens	70	70
Noncarcinogens	25	15

TABLE W-8 DAILY INTAKE - ADULT
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene		1.293E-02	0.6	298	0.12	25	70	9125	1.086E-05
2-Methylnaphthalene	*	0.000E+00	0.6	298	0.12	25	70	9125	0.000E+00
1,4-Dichlorobenzene		1.068E-01	0.6	298	0.12	25	70	9125	8.966E-05
Benzene		1.933E-02	0.6	298	0.12	25	70	9125	1.624E-05
Lead, Dissolved	*	0.000E+00	0.6	298	0.12	25	70	9125	0.000E+00

* not VOCs

TABLE W-9 DAILY INTAKE - CHILD
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene		1.293E-02	0.600	48	0.12	15	27	5475	4.534E-06
2-Methylnaphthalene	*	0.000E+00	0.600	48	0.12	15	27	5475	0.000E+00
1,4-Dichlorobenzene		1.068E-01	0.600	48	0.12	15	27	5475	3.744E-05
Benzene		1.933E-02	0.600	48	0.12	15	27	5475	6.780E-06
Lead, Dissolved	*	0.000E+00	0.600	48	0.12	15	27	5475	0.000E+00

* not VOCs

TABLE W-10 DAILY INTAKE - ADULT
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene		1.293E-02	0.6	298	0.12	25	70	25550	3.877E-06
2-Methylnaphthalene	*	0.000E+00	0.6	298	0.12	25	70	25550	0.000E+00
1,4-Dichlorobenzene		1.068E-01	0.6	298	0.12	25	70	25550	3.202E-05
Benzene		1.933E-02	0.6	298	0.12	25	70	25550	5.799E-06
Lead, Dissolved	*	0.000E+00	0.6	298	0.12	25	70	25550	0.000E+00

* not VOCs

TABLE W-11 DAILY INTAKE - CHILD
INHALATION OF GROUNDWATER
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/cu m)	Inhalation Rate (cu m/hr)	Exposure Frequency (days/year)	Exposure Time (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Intake Rate (mg/Kg-day)
Tetrachloroethylene		1.293E-02	0.600	48	0.12	15	27	25550	9.715E-07
2-Methylnaphthalene	*	0.000E+00	0.600	48	0.12	15	27	25550	0.000E+00
1,4-Dichlorobenzene		1.068E-01	0.600	48	0.12	15	27	25550	8.023E-06
Benzene		1.933E-02	0.600	48	0.12	15	27	25550	1.453E-06
Lead, Dissolved	*	0.000E+00	0.600	48	0.12	15	27	25550	0.000E+00

* not VOCs

TABLE W-12 EXPOSURE ASSESSMENT PARAMETERS - DERMAL CONTACT WITH GROUNDWATER
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

PARAMETER	ADULT	CHILD
Skin Surface Area Available for Contact (sq cm)	19400	13300
Exposure Time (hrs/day)	0.25	0.25
Dermal Permeability Constant *	0.00084	0.00084
Exposure Frequency (days/year)	298	48
Exposure Duration (years)	25	15
Body Weight, Kg	70	27
Averaging Time		
Carcinogens	70	70
Noncarcinogens	25	15
Conversion Factor	0.001	

* Predicted PC (Table 5-7 of U.S. EPA, 1992a)

TABLE W-13 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a)	1.369E-03	0.4	19400	298	0.25	25	70	9125	0.001	3.097E-05
2-Methylnaphthalene	(c)	2.486E-02	0.001	19400	298	0.25	25	70	9125	0.001	1.406E-06
1,4-Dichlorobenzene		1.130E-02	0.00084	19400	298	0.25	25	70	9125	0.001	5.371E-07
Benzene	(a)	3.900E-03	0.1	19400	298	0.25	25	70	9125	0.001	2.206E-05
Lead, Dissolved	(a)	8.487E-03	0.000004	19400	298	0.25	25	70	9125	0.001	1.920E-09

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

TABLE W-14 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Noncarcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a)	1.369E-03	0.4	13300	48	0.25	15	27	5475	0.001	8.866E-06
2-Methylnaphthalene	(c)	2.486E-02	0.001	13300	48	0.25	15	27	5475	0.001	4.026E-07
1,4-Dichlorobenzene		1.130E-02	0.00084	13300	48	0.25	15	27	5475	0.001	1.538E-07
Benzene	(a)	3.900E-03	0.1	13300	48	0.25	15	27	5475	0.001	6.316E-06
Lead, Dissolved	(a)	8.487E-03	0.000004	13300	48	0.25	15	27	5475	0.001	5.498E-10

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

TABLE W-15 DAILY INTAKE - ADULT
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a)	1.369E-03	0.4	19400	298	0.25	25	70	25550	0.001	1.106E-05
2-Methylnaphthalene	(c)	2.486E-02	0.001	19400	298	0.25	25	70	25550	0.001	5.023E-07
1,4-Dichlorobenzene		1.130E-02	0.00084	19400	298	0.25	25	70	25550	0.001	1.918E-07
Benzene	(a)	3.900E-03	0.1	19400	298	0.25	25	70	25550	0.001	7.879E-06
Lead, Dissolved	(a)	8.487E-03	0.000004	19400	298	0.25	25	70	25550	0.001	6.859E-10

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).
(c) Experimentally measured PC value for water, used in the absence of chemical specific experimental or predicted PC values (Table 5-3 of U.S. EPA, 1992a).

TABLE W-16 DAILY INTAKE - CHILD
GROUNDWATER DERMAL CONTACT
FUTURE LAND USE SCENARIO

Carcinogenic Effect Exposure Assessment
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical		Chemical Concentration (mg/l)	Dermal Permeability (cm/hr)	Skin Surface Area (sq cm)	Exposure Frequency (days/year)	Exposure Time (hrs/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Conversion Factor (l/cu cm)	Intake Rate (mg/Kg-day)
Tetrachloroethylene	(a)	1.369E-03	0.4	13300	48	0.25	15	27	25550	0.001	1.900E-06
2-Methylnaphthalene	(c)	2.486E-02	0.001	13300	48	0.25	15	27	25550	0.001	8.628E-08
1,4-Dichlorobenzene		1.130E-02	0.00084	13300	48	0.25	15	27	25550	0.001	3.295E-08
Benzene	(a)	3.900E-03	0.1	13300	48	0.25	15	27	25550	0.001	1.353E-06
Lead, Dissolved	(a)	8.487E-03	0.000004	13300	48	0.25	15	27	25550	0.001	1.178E-10

(a) Experimentally measured PC (Table 5-3 of U.S. EPA, 1992a).

TABLE W-17 CANCER ESTIMATE - GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	1.140E-05	2.857E-06	NO	0.051	B2	Liver	CA EPA 92	5.815E-07		1.457E-07	
2-Methylnaphthalene	2.071E-04	5.190E-05	NO	NO EVIDENCE				0.000E+00		0.000E+00	
1,4-Dichlorobenzene	9.417E-05	2.359E-05	NO	0.024	B2	Liver	HEAST 93	2.260E-06		5.663E-07	
Benzene	3.249E-05	8.141E-06	NO	0.029	A	Leukemia	IRIS, 1993	9.422E-07		2.361E-07	
Lead, Dissolved	7.071E-05	1.772E-05	NO	NO DATA	B2	Kidney		0.000E+00		0.000E+00	
Total									3.784E-06		9.481E-07

TABLE W-18 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INGESTION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	3.193E-05	1.333E-05	NO	0.01	Hepatotoxicity	IRIS, 1993	1	3.193E-03		1.333E-03	
2-Methylnaphthalene	5.799E-04	2.422E-04	NO	0.03		IRIS, 1993	1	1.933E-02		8.073E-03	
1,4-Dichlorobenzene	2.637E-04	1.101E-04	NO	NO DATA		NA	NA				
Benzene	9.097E-05	3.799E-05	NO	NO DATA		NA	NA				
Lead, Dissolved	1.980E-04	8.268E-05	NO	NO DATA		NA	NA				
Total									2.252E-02		9.406E-03

1) Chronic RfD for pyrene was used.

TABLE W-19 CANCER ESTIMATE - GROUNDWATER INHALATION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	3.877E-06	9.715E-07	NO	0.0018	B2	Leukemia, Liver	CA EPA 92	6.979E-09		1.749E-09	
2-Methylnaphthalene	0.000E+00	0.000E+00	NO	NO EVIDENCE				0.000E+00		0.000E+00	
1,4-Dichlorobenzene	3.202E-05	8.023E-06	NO	0.04	C	NA	CA EPA 92	1.281E-06		3.209E-07	
Benzene	5.799E-06	1.453E-06	NO	0.029	A		IRIS, 1993	1.682E-07		4.213E-08	
Lead, Dissolved	0.000E+00	0.000E+00	NO	NO DATA	B2	NA	NA	0.000E+00		0.000E+00	
Total									1.456E-06		3.648E-07

1) Inhalation SF converted from unit risk.

TABLE W-20 CHRONIC HAZARDOUS INDEX ESTIMATE - GROUNDWATER INHALATION
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD (mg/kg day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Children Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	1.086E-05	4.534E-06	NO	0.01	NA	IRIS 93	1	1.086E-03		4.534E-04	
2-Methylnaphthalene	0.000E+00	0.000E+00	NO	0.03	NA	HEAST 93	NA	0.000E+00		0.000E+00	
1,4-Dichlorobenzene	8.966E-05	3.744E-05	NO	0.2	Liver, Kidney	NA	NA	4.483E-04		1.872E-04	
Benzene	1.624E-05	6.780E-06	NO	NO DATA	NA	NA	NA				
Lead, Dissolved	0.000E+00	0.000E+00	NO	NO DATA	NA	NA	NA				
Total									1.534E-03		6.406E-04

1) RfD for corresponding oral RfD was used.

TABLE W-21 CANCER ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Carcinogenic Effects
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	SF * (mg/kg-day)^-1	Weight of Evidence	Type of Cancer	SF Source	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	1.106E-05	1.900E-06	YES	0.051	B2	Liver	CA EPA 92	5.641E-07		9.689E-08	
2-Methylnaphthalene	5.023E-07	8.628E-08	YES	NO EVIDENCE				0.000E+00		0.000E+00	
1,4-Dichlorobenzene	1.918E-07	3.295E-08	YES	0.024	B2	Liver	HEAST 93	4.604E-09		7.908E-10	
Benzene	7.879E-06	1.353E-06	YES	0.029	A	Leukemia	IRIS, 1993	2.285E-07		3.925E-08	
Lead, Dissolved	6.859E-10	1.178E-10	YES	NO DATA	B2	Kidney		0.000E+00		0.000E+00	
Total									7.972E-07		1.369E-07

* Adjusted from administered to absorbed using and absorption efficiency of PCE = 1, 1,4 DCB = 1, Benzene = 1, Lead = .05.

TABLE W 22 CHRONIC HAZARDOUS INDEX ESTIMATE - DERMAL CONTACT WITH GROUNDWATER
FUTURE LAND USE SCENARIO - ADULTS AND CHILDREN

Noncarcinogenic Effects
Site 9, Radar Tower, Alpena CRTC, Alpena, MI

Chemical	Adult CDI (mg/kg-day)	Child CDI (mg/kg-day)	CDI Adjusted for Absorption	RfD * (mg/kg-day)	Critical Effect	RfD Source	Modifying Factor	Adult Chemical-Specific Risk	Total Pathway Risk	Child Chemical-Specific Risk	Total Pathway Risk
Tetrachloroethylene	3.097E-05	8.866E-06	NO	0.01		IRIS, 1993	1	3.10E-03		8.87E-04	
2-Methylnaphthalene	1.406E-06	4.026E-07	NO	0.005	Hepatotoxicity	IRIS, 1993	1	2.81E-04		8.05E-05	
1,4-Dichlorobenzene	5.371E-07	1.538E-07	NO	NO DATA			1				
Benzene	2.206E-05	6.316E-06	NO	NO DATA			1				
Lead, Dissolved	1.920E-09	5.498E-10	NO	NO DATA			1				
Total									3.38E-03		9.67E-04

* Adjusted from administered to absorbed using and absorption efficiency of , PCE = 1.0, 2-Methylnapthalene = .017.

Groundwater Solute Transport Model Data - Site 9

Theoretical Background

A two-dimensional Method of Characteristics (MOC) solute transport model (Konikow and Bredehoeft, 1989) was used for preliminary examination of contaminant migration within the shallow aquifer beneath the Alpena CRTC. The model is designed to calculate transient changes in solute concentrations within groundwater by simultaneously solving partial differential equations describing groundwater flow and transport and computes the change in a chemicals concentration over time. Changes in chemical concentrations over time are caused by the processes of convective transport, hydrodynamic dispersion, and mixing from fluid sources. This model couples the groundwater flow equation with solute transport equations.

The flow equation can be approximated by an implicit finite-difference equation. The model area is discretized into a rectangular grid with each square being a node. The finite difference equation is solved numerically for each node in the grid using an iterative alternating-direction implicit (ADI) procedure.

After the hydraulic head distribution is calculated, the velocity of groundwater flow can be computed at each node. The expression for average velocity of groundwater can be derived from Darcy's law. The groundwater velocity at each node is calculated utilizing an explicit finite-difference approximation of Darcy's law. The computer program uses an alternating-direction implicit procedure to solve a finite-difference approximation to the groundwater flow equation, and it uses the method of characteristics (MOC) to solve the solute transport equation. MOC uses a particle tracking procedure to represent convective transport and a two-step, explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks, and divergence of velocity.

A number of assumptions are inherent in the solute transport model:

1. Darcy's law is valid and hydraulic head gradients are the only significant driving mechanism for fluid flow.

2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.

3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.

4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.

5. Ionic and molecular diffusion are negligible contributors to the total dispersive flux.

6. Vertical variations in head and concentrations are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Transport Model Input

A model grid of 32 columns by 19 rows with a 250 foot lateral spacing was used. Specified head cells were used at nodes corresponding to the South Branch of the Thunder Bay River, at nodes along the eastern boundary of the model grid area, and also at the sinkhole in the northeastern portion of the model. Groundwater elevations measured during September, 1993 were used as initial input into the transport model. Hydraulic conductivity values were calculated from slug tests performed at Alpena CRTC (Engineering Science, 1989; Earth Technology, 1994). Values of hydraulic conductivity range from 12 feet/day at Site 4 to 278 feet/day at Site 3.

Aquifer thickness values were obtained from drilling records of monitoring wells and soil borings obtained from the SI and RI field activities. Values listed are from logs in which the thickness of the shallow aquifer was clearly discernible, and ranged from 20 feet at Site 5 to 65 feet at Site 8. Transmissivity values were calculated by multiplying the calculated hydraulic conductivity values by the aquifer thickness. Transmissivity ranges from 420 ft^2/day at TF4-MW3 to 15,290 ft^2/day at CG3-MW5.

Monitoring of the discharge of springs into the sinkhole was performed during the SI (Engineering Science, 1990) and an estimate of approximately 18,000 gallons of water per day discharging into the sinkhole was calculated. In order to obtain a numerical estimate of discharge into the sinkhole for the model, MODFLOW (McDonald and Harbaugh, 1988), a 3- dimensional finite-difference groundwater flow model was used. MODFLOW was used because of its ability to simulate the effect of head-dependent groundwater flow into a groundwater sink (i.e. the sinkhole). This package was not available in MOC. The same model parameters and boundary conditions were used within MODFLOW as in MOC. Based upon hydraulic head data collected in September 1993, discharge from the shallow aquifer into the sinkhole is approximately 30,000 gallons per day.

The dispersivity of an aquifer in two dimensions is described by the longitudinal dispersion, the transverse dispersion and the ratio of the two (Fetter, 1993). As a contaminant plume moves further from its initial location within the aquifer by advection with the groundwater flow, the plume spreads. The spreading in the direction of groundwater flow is the longitudinal dispersion, the spreading in the direction perpendicular to the groundwater flow is known as the transverse dispersion (Fetter, 1993). The values of the dispersion coefficients are typically derived via bench scale tests, aquifer tests, or calibration of contaminant transport models. Since no data presently exists describing dispersivity within the shallow aquifer beneath the Alpena CRTC and insufficient data exists to allow for derivation of dispersivity via model calibration, moderate values of 100 feet for longitudinal dispersivity and 30 feet for transverse dispersivity were chosen (Gillham and Cherry, 1982). A more complete description of the model is given in the report, Preliminary Groundwater Modeling Effort, Earth Technology, August 1993.

Model Calibration:

The groundwater flow model was calibrated with respect to the September 1993 groundwater elevation measurements. Calibration of the groundwater flow model was accomplished by defining a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field-measured values within a preestablished range of error (Anderson and Woessner, 1992). In order to match field measured values for hydraulic head as determined during September 1993, a few modifications were made to the preexisting groundwater flow model. These changes included updating the initial head array, modeling the sinkhole as a constant head cell to account for the large gradient changes in the vicinity of the sinkhole and including recharge to the model at a rate of 9 inches per year over the whole model area. By adjusting these parameters, an acceptable level of calibration was achieved. An acceptable level of calibration was defined as a root mean squared error (RMS) of less than 2 feet. The RMS, or the standard deviation is the average squared difference in measured and simulated heads and is given by the equation:

$$RMS = [1/n \sum_{i=1}^{n} (h_m - h_s)_i^2]^{0.5}$$

n = number of wells
h_m = measured head
h_s = model simulated head

Certain portions of the model may have values above the goal of 2 feet while others fall much below this value. The RMS represents the average error present in the model. The following provides a summary of the final calibrated heads for the flow model.

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
MP2MW1	10,25	679.69	676.68	3.01
MP2MW3	10,22	675.51	675.46	0.05
MP2MW4_5*	11,23	675.34	675.70	-0.36
MP2MW6	11,20	674.86	674.52	0.34
CG3MW1	6,24	677.38	676.69	0.69
CG3MW2	7,22	676.29	675.78	0.51
CG3MW3	9,23	676.50	675.98	0.52
CG3MW4_5*	8,23	676.41	676.08	0.33

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
CG3MW7	8,20	675.64	674.80	0.84
TF4MW1	7,9	667.23	668.83	-1.60
TF4MW2	8,10	659.61	664.22	-4.61
TF4MW3_4*	9,10	658.21	660.06	-1.85
SF5MW1	12,6	674.15	671.34	2.81
SF5MW2	14,5	675.32	672.67	2.65
SF5MW3_4*	13,6	676.46	671.64	4.82
SF5MW6	13,5	674.26	672.40	1.86
LF6MW1	14,9	672.1	670.40	1.70
LF6MW2	14,8	672.68	670.72	1.96
LF6MW3	14,10	671.93	670.21	1.72
LF6MW4	16,7	672.75	671.91	0.84
LF6MW5	15,7	673.07	671.56	1.51
LF6MW6	13,10	671.17	669.67	1.50
LF6MW8	15,9	673.12	670.78	2.34
HN8MW1	5,22	676.96	675.93	1.03
HN8MW2	6,19	675.31	674.50	0.81
HN8MW3_4*	7,21	676.01	675.35	0.66
RT9MW1	6,16	673.06	672.78	0.28
RT9MW2	7,14	668.21	670.81	-2.60
RT9MW3	9,15	670.72	671.26	-0.54
RT9MW4_5*	8,14	667.47	670.32	-2.85
RT9MW6	8,16	670.58	672.33	-1.75
S1MW2	13,26	677.39	676.63	0.76
S1MW3	13,27	677.15	676.98	0.17
S1MW11	15,24	675.72	675.67	0.05
S1MW12	16,25	674.55	675.94	-1.39

Well #	Row, Col	Measured Head (ft)	Simulated Head (ft)	Measured - Simulated Head (ft)
S1MW13	14,24	675.21	675.76	-0.55
S1MW14	14,25	673.92	676.14	-2.22
MP2MW2	12,24	675.57	675.96	-0.39

* Indicates that more than one well is present in each node and an average value for hydraulic head was used.

Sum of Squared Residuals = 128.78/38 = 3.3891
Root Mean Squared Error = 1.84

It should also be noted that the model was calibrated with respect to the September 1993 water level data and should only be considered calibrated with respect to this data. More information on the water level fluctuation through time would be needed to perform a transient calibration. The model was not calibrated with respect to concentration data, but only with respect to hydraulic head.

Model Assumptions and Limitations

* The model domain consisted only of the shallow unconfined aquifer (i.e. one layer).

* The initial head data input to the transport model are results of measurements taken in September 1993.

* Initial concentrations of compounds are results of the Round IV sampling event which was conducted from July to September 1993.

* Hydraulic conductivity values are the result of slug tests performed in November, 1987 and September 1993.

* The model was calibrated with respect to hydraulic head using September 1993 water level data and should only be considered calibrated with respect to September 1993 water level data.

* The flow model was assumed to be at steady-state with respect to hydraulic head.

Site 9

Several chemicals were detected at Site 9 above MDNR Type A or Type B criteria. These chemicals include PCE, Benzene, 1,4- Dichlorbenzene, Lead, and 2- Methylnapthalene at concentrations of 1.5, 3.9, 18, 15.9, and 47 ug/l, respectively. These chemicals were all present at well RT9MW6, while PCE was detected in wells RT9MW4 and RT9MW5. However, due to numberical errors associated with the very large gradient changes near the sinkhole, PCE was only modeled in RT9MW6. The chemical data was input to the model at the node corresponding to well RT9MW6 and concentrations for the various analytes were monitored in the sinkhole with respect to time.